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VOLUME 104 (3): DECEMBER 2007

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CONTENTS

ECOLOGICAL ASPECTS OF INDIAN SPINY-TAILED LIZARD *UROMASTYX HARDWICKII* IN KUTCH
Sutirtha Dutta and Yadvendradev Jhala 255

PREDATORS OF NON-PENAEID PRAWNS OF MUMBAI COAST
V.D. Deshmukh 266

HEPATICS AND ANTHOCEROTES (BRYOPHYTA) OF TAMIA AND PATALKOT VALLEY (DISTRICT CHHINDWARA), MADHYA PRADESH
A.K. Asthana and Virendra Nath 275

SIZE COMPOSITION AND MORPHOMETRY OF INCIDENTALLY CAPTURED SEA TURTLES AT VIZHINJAM, SOUTH-WEST COAST OF INDIA
P. Kannan and M. Rajagopalan 288

AVIFAUNA OF THE ANDAMAN ISLANDS: PRELIMINARY INVENTORY AND DISTRIBUTIONAL PATTERNS
Priya Davidar, K. Yoganand, T. Ganesh and K. Geetha Nayak 298

FAUNAL DIVERSITY IN PRAWNS AND CRABS IN DIGHA AND ADJACENT COAST IN WEST BENGAL WITH NOTES ON THE RELATIONSHIP OF THEIR ABUNDANCE WITH PHYSICO-CHEMICAL PARAMETERS
T.K. Chatterjee, Akmal Husain and Santanu Mitra 311

DISTRIBUTION AND STATUS OF THE ASIATIC BLACK BEAR *URSUS THIBETANUS* IN INDIA
S. Sathyakumar and A. Choudhury 316

STUDIES ON THE OCCURENCE, AVAILABILITY AND MARKETING OF CRAB (*SCYLLA* SPP.) BY CRAB MONITORING PROGRAMME OF RATNAGIRI DISTRICT, SOUTH KONKAN COAST OF MAHARASHTRA, INDIA
Vivek R. Vartak, Narendra D. Chogale and Sharad G. Belsare 324

ASPECTS OF NESTING BIOLOGY OF *CROCODYLUS POROSUS* AT BHITARKANIKA, ORISSA, EASTERN INDIA
G.V. Gopi, Bivash Pandav and Sangeeta Angom 328

NEW DESCRIPTIONS

A NEW FAIRY SHRIMP SPECIES, *BRANCHINELLA NALLURENSIS* FROM SOUTH INDIA
C.S. Velu and N. Munuswamy 334

DESCRIPTION OF A NEW SPECIES OF *CERCERIS* LATREILLE (HYMENOPTERA: SPHECIDAE: PHILANTHINAE: CERCERINI) ALONG WITH A NEW RECORD FROM INDIA
A. Coumar and Debjani Dey 339

MISCELLANEOUS NOTES

MAMMALS

1. First record of Lesser False Vampire *Megaderma spasma* (Linnaeus, 1758) in Madhya Pradesh, India
K.R. Senacha 343

2. Second record of albino Fivestriped Palm Squirrel *Funambulus pennanti* Wroughton from Udaipur, Rajasthan
Satya Prakash Mehra, Jitendra Singh Kharwar and Narayan Singh Kharwar 344

3. Occurrence of Asiatic Brushtailed Porcupine *Atherurus macrourus* (Linn. 1758) at Mizoram, India
Naresh Chaturvedi, M. Sawmliana and Vinod Patil 345

4. Predation on Chital *Axis axis* by Wild Pig *Sus scrofa* in Bandhavgarh National Park
Satyaranjan Behera and Rajendra Prasad Gupta 345

5. Comments on — Debarking of Teak *Tectona grandis* Linn. F. by Gaur *Bos gaurus* H. Smith during summer in a tropical dry deciduous habitat of Central India by Pasha, M.K.S., G. Arindran, K.P. Sankaran and Q. Qureshi, 2002: *JBNHS 99(2)*: 238-244
Hilaluddin 346

BIRDS

6. A sight record of Mew Gull *Larus canus* in Goa
Paul Holt 347

7. Wintering range extension of White-throated Bushchat *Saxicola insignis* Gray in India
Kulojyoti Lahkar and Mridu Paban Phukan 348

8. Forest Wagtail *Dendronanthus indicus* in Jamnagar medical campus
Maulik S. Varu, Jalpan C. Rupapara and Purvesh K. Kacha 349

9. Further records of Great Knot *Calidris tenuirostris* and Red Knot *Calidris canutus* from the north-east coast of India
S. Balachandran and P. Sathiyaselvam 350

10. Unusual occurrence of Fulvous Whistling-duck *Dendrocygna bicolor* (Vieillot 1816) at Chilika Lake
P. Sathiyaselvam 351

11. Comments on the review by Asad Rahmani, on 'Handbook on Indian Wetland Birds and their Conservation'
C. Radhakrishnan 352

REPTILES

12. Food and feeding habits of the Green Turtle *Chelonia mydas* in relation to marine plants in the Gulf of Mannar Biosphere Reserve, India
P. Kannan and M. Rajagopalan 352
13. First record of Slender Racer *Coluber gracilis* (Günther, 1862) (Serpentes: Colubridae) from Rajasthan
Satish Kumar Sharma and Shailesh Nagar 355

FISH

14. Possibility of breeding grounds of Mahseer in the Paisuni R. (Chitrakoot Dham), its ecology, and status of *Tor tor* (Hamilton) in the north Vindhyan Rivers
P. Nautiyal, A.C. Dwivedi, A. Shivam and K.R. Singh 355
15. On the record of *Garra ceylonensis* Bleeker 1863: A Sri Lankan cyprinid Fish from India
K.V. Radhakrishnan and B. Madhusoodana Kurup 357
16. Range extension of *Salmostoma sardinella* (Osteichthyes: Cyprinidae) to streams of Tamil Nadu, Kerala and Karnataka part of Western Ghats
M. Arunachalam, J.A. Johnson, A. Manimekalan, A. Sankaranarayanan, R. Soranam, P. Sivakumar and P.V. Kalavathi 359
17. On a record of a young teratoid *Carcharhinus hemiodon*
A. Jesu Arockia Raj, S. Seetharaman and M.A. Haniffa 360

INSECTS

18. Notes on the behaviour of some Dung Beetles in and around Bangalore
K. Veenakumari and G.K. Veeresh 361
19. Protein profile of Haemolymph from *Apis* species
Neelima R. Kumar and Lalita Negi 364
20. A prey-predator link between the Rock Bee *Apis dorsata* and the False Vampire Bat *Megaderma lyra* Geoffroy based on their circadian rhythms
Sutapa Biswas 365
21. A new larval food plant of the Common Albatross *Appias albina* (Boisduval), with a note on its migration in Kerala
Vinayan P. Nair 366
22. Some observations of Plains Cupids *Euchrysops pandava* on *Cycas circinalis*
K.R. Kishen Das 367

OTHER INVERTEBRATES

23. Occurrence of Giant Isopod *Bathynomus giganteus* A. Milne Edwards 1879 in the Chennai coastal waters
P.S. Lyla, P. Murugesan, K.P. Manikandan and S. Ajmal Khan 368
24. A note on the capture of 'Giant Isopod', *Bathynomus giganteus* A. Milne Edwards, 1879 off Mangalore Coast, India
T. Harish Nayak, A.P. Dineshbabu and P.U. Zacharia ... 369

BOTANY

25. *Nonea caspica* (Willd.) G. Don. (Boraginaceae) — a new record for India
Rohitash Kumar Bhatia and Suman C. Sharma 370
26. An amplified description of a hitherto uncommon species *Leucothoe griffithiana* C.B. Clarke (Ericaceae)
S. Panda 371
27. New records of five taxa of Ericaceae from India
S. Panda, M. Sanjappa and R.K. Bhakat 373
28. A little known plant species of Gujarat *Tephrosia collina* Sharma var. *lanuginocarpa* Sharma
P.S. Nagar 378
29. Additions to the flora of Andaman and Nicobar islands, India
C. Sudhakar Reddy, P.R.C. Prasad and C.B.S. Dutt 379

Cover Photograph: Spiny-tailed Lizard
Uromastyx hardwickii
By Kedar Bhide

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ECOLOGICAL ASPECTS OF INDIAN SPINY-TAILED LIZARD *UROMASTYX HARDWICKII* IN KUTCH

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Allocation of three major resources – space, food and time by the Indian Spiny-tailed Lizard *Uromastyx hardwickii* (Lacertilia: Agamidae) was studied in the grassland habitat of Kutch. The activity budget, behavioural thermoregulation, foraging behaviour and social interactions were observed using focal animal sampling combined with scan animal sampling and *ad libitum* sampling. Seasonal food habits were estimated from bite counts and pellet analysis. Ranging patterns were studied by mapping individually identified lizards. The activity pattern shifted from bimodality in summer (duration=119 min/day, SE=12, n=25 lizards) to unimodality in monsoon (duration=93 min/day, SE=5, n=23 lizards). The body pigmentation changed from dark to light as the temperature increased. The diet comprising grasses (*Chrysopogon* and *Cymbopogon*), insects (ants, termites and locusts) and shrubs (*Clerodendron*) in summer, narrowed to herbs (*Borreria, Euphorbia, Indigofera*, etc.) and grasses (*Chrysopogon* and *Cymbopogon*) in the monsoon. The density of active burrows was 42.45/ha in summer and 66.04/ha in monsoon. The average home range was 0.2 ha (SE=0.04, n=23) in summer and 0.05 ha (SE =0.01, n=20 lizards) in the monsoon. Male home ranges (0.39 ha in summer, SE=0.08, n=6 and 0.12 ha in monsoon, SE=0.03, n=4) were larger than those of females (0.15 ha in summer, SE=0.04, n=4 and 0.03 ha in monsoon, SE=0.02, n=3) and juveniles (0.12 ha in summer, SE=0.02, n=10 & 0.03 ha in monsoon, SE=0.01, n=7). Aggressive behaviours with low overlaps in core areas and extensive overlapping in fringe areas of individual home ranges indicated territoriality in core areas, but hierarchically or temporally spaced resource sharing in the peripheries of home ranges.

Key words: Spiny-tailed Lizard, *Uromastyx hardwickii*, behaviour, activity budget, thermoregulation, food habits, home range, mating structure, density

INTRODUCTION

The foraging behaviour of lizards is correlated with their size, morphology, ecology, reproduction, metabolism and movements, and these relations are more prominent in the case of herbivory, suggesting an evolutionary relationship among these parameters (Vitt and Congdon 1978; Huey and Pianka 1981; Pietruszka 1986; King 1996; Perry and Pianka 1997; Pianka *et al.* 1998). Plants put forward an array of defences against being foraged, constraining an herbivore's diet by toxin intake, limited nutrient intake, slow digestion rates, gut fill and in the case of ectothermic herbivores, daily feeding time (Stephens and Krebs 1986). Thus, a pure plant diet favours specialisations compared to a carnivorous diet. Out of 3,300 species of modern lizards existing today (Sokol 1971; Pough *et al.* 1989; King 1996) only 90, including the Spiny-tailed lizards, *Uromastyx* spp. have an herbivorous diet (King 1996).

Recent phylogenetic studies on *Uromastyx*, previously considered as agamids, showed that they could potentially be classified into a new family, the Uromastycidae (Böhme 1982; Moody 1980; Borsuk-Bialynicka and Moody 1984; Das 2002; but see Joger 1991). Indian Spiny-tailed lizard *Uromastyx hardwickii* (Gray), one of the fifteen under genus *Uromastyx*, is a dweller of arid, open and scrubby regions (Das 2002) and has a patchy distribution from north-western India to Pakistan and Afghanistan (Khan and Mahmood 2004). It forages mainly on grasses, shrub leaves, flowers and fruits, and obtains water from food and metabolism of subcutaneous fat (Daniel 2002; Khan and Mahmood 2004). The activity of *Uromastyx* is retarded in winter and intensified in spring and summer, with mating occurring in March or April. The female lays around 14 eggs between April and May-June (Daniel 2002; Das 2002; Khan and Mahmood 2004). Typical populations of this solitary burrow dweller occur in loose associations of several individuals ranging from 10 to 100 per sq. km, often with nearly 50 adults in a colony (Bhatnagar *et al.* 1973; Das 2002; Knapp 2004). They are known to occupy extensive territories (Zug 1993), but details on the nature of their territoriality is lacking.

The spatial distribution of animals is determined by resource dispersion and sociality (Johnson *et al.* 2002). The home range parameters and dynamics reveal various aspects of behavioural ecology (Ferner 1974; Gans and Pough 1982). The territory, the defended and exclusively used part of the home range, may include it in its entirety or some ecologically significant sites or routes (Burt 1943; Schoener 1968; Stamps 1977; Smith 1985). In lizards, the spacing system varies from

clear territoriality to broadly overlapping home ranges (Rose 1982; Smith 1985).

'Vulnerable' (as declared by the IUCN) Indian Spiny-tailed Lizard populations, surviving under the threats of changing land use and trade for supposed aphrodisiac properties, have not been subjected to any detailed ecological study. In this study we evaluate the temporal activity pattern, ranging patterns, social interactions, food and foraging behaviour of the species.

STUDY AREA

The study was conducted in a typical Spiny-tailed lizard habitat in Abdasa taluka, the south-western province of Kutch district, in the state of Gujarat in western India. Kutch is mostly occupied by Jurassic rocks, bears traces of the ancient Indus Valley civilization and partially detached from the mainland owing to the condition of the Rann (Williams 1958). It belongs to the semi-desert ecological zone where summer commences in March and continues until late June. May experiences the highest air temperatures of 40-45 °C. Precipitation is scanty and stochastic, with an annual average of 384 mm. The rains arrive by early July in 65% of the years while late onset is recorded in 35%. A high evapo-transpiration rate results in drying up of most natural water sources. Winters are relatively severe, extending from middle of November to February. The minimum temperatures are recorded in January, with an average temperature of 5 °C. The vegetation in this area has been classified as Northern Tropical Thorn Forest (6B) and sub-classified as Desert Thorn Forest (6B/C1) as per the classification of forest types by Champion and Seth (1968). This area, lying in Biogeographic Zone 3B (Kachchh Desert) (Rodgers *et al.* 2002), serves as the habitat of several important species of fauna, some of which have been declared as Schedule I under the Wildlife (Protection) Act, 1972 (Home 2005).

METHODOLOGY

An area of 2.1 ha was selected and delineated in Kanauthia Daun (23°14' N; 68°59'E), a grassland habitat with a good population of Spiny-tailed Lizards. Infrequent patches of shrub enhance the visibility in this part. The intensive study area, with details of the vegetation was mapped using a compass, range finder and hand-held GPS unit (Garmin 12 XLS).

Individual lizards were identified from visual clues: size, sex (males have a longer, larger tail with a bulbous base) and natural marks (stripes and blotches in young, body notches, broken tails, missing spines and scales, sloughed skin etc.). Identified lizards were continuously followed one at a time for the first two weeks to locate their burrows which were mapped, and a detailed catalogue was prepared. Since adult, sub-adult and juvenile lizards used a single burrow each, a total count of lizards was done once in each season for density and age structure estimations and nearest neighbour analysis was performed for the pattern of burrow distribution. The average distance of hatchling burrows from adult burrows was tested with that from equal number of any burrow (all selected randomly) through a 't' test to find any spatial affinity between adults and their hatchlings. Morphometric data were obtained whenever lizards were rescued from poachers.

Observations were done from a hide with 8×50 binoculars in summer and monsoon, and data were recorded after an initial period of habituation for two weeks. Scan animal sampling (Altmann 1973) at 10 minutes intervals was used to record the activity pattern from 0800 to 1730 hrs in summer and 0900 to 1830 hrs in the monsoon. The activity was categorised into six discrete states: scanning, basking, moving, foraging, social interactions and escape. Activity pattern was quantified as number of active lizards at any time expressed as percentage of the maximum lizard count for the day.

Identifiable individuals' locations were recorded on the map of the study site for each scan using a compass and range finder with reference to mapped features of the study area. The home range size was estimated from these locations using a 95% fixed kernel contour (Worton 1989) and the core area was delineated from a 50% isopleth. The percent overlap between a pair of neighbouring lizard home ranges was computed. *Ad libitum* sampling was done for territorial and other social behaviours. Territorial behaviour was classified as only chase (low intensity), displays (medium intensity) and aggressive fights (high intensity). Occurrences of aggressive behaviour were expressed as aggression-encounter rates (AER= frequency of occurrence of aggressive behaviour/ sampling day/ha).

Ambient and ground temperatures were recorded at every half hour intervals using a Hick's air thermometer. Corresponding to each temperature record, the numbers of active juvenile, sub-adult, adult female and adult male lizards were recorded. The average lizard sighting (activity rate) was calculated for each temperature class. The body colours of individuals within 30 m were categorised into dark brown, dark olive, light olive, yellow and pale white and analysed for any pigmentation trend in relation to ambient and ground temperatures. Bite counts of lizards in proximity to the hide (<30 m) were recorded by focal sampling of individual lizards between subsequent scans. On the average, a scan took 2 minutes, and an interim 8 minutes were used for focal sampling of foraging lizards. The area sampled for bite counts was about 13% of the study area and had a similar vegetation

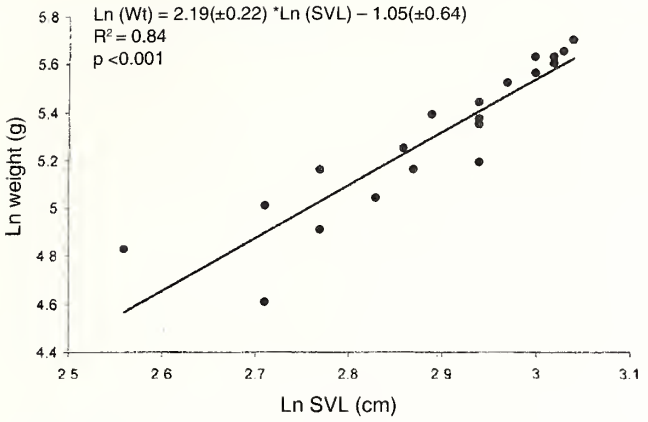

Fig. 1: Relationship between log-transformed snout-vent length (SVL) and weight of *Uromastyx hardwickii*

composition. Data were recorded as the number of bites of different food items using a tally counter. An actively foraging, focal lizard was observed till >20 to <200 bites were recorded or it moved away from the 30 m radius or stopped foraging. The dietary composition was also studied through faecal pellet analysis (Korschgen 1980). Three random transects of 100 m x 2 m were sampled for pellets. Pellets were collected on every alternate day, weighed accurately and transferred into Zip locks for later analysis. However, pellet collection was poor in the monsoon due to the faster decomposition rate, and this method was not used for diet analysis in the monsoon. Simpson's index of diversity, B= $1/\sum$ pi2 (Mac Arthur 1972) where pi indicates the ith food item, was used to quantify the trophic niche breadth. The dietary preference was estimated through compositional analysis (Aebischer *et al.* 1993). The vegetation was sampled by hand plucking all available bites of each food species from randomly selected 1 m x 1 m quadrates for grasses and herbs and 4 m x 4 m quadrats for shrubs to quantify the forage availability. Bites were simulated by hand plucking of plant parts, which were oven dried in paper bags at 70 °C to obtain the dry weights (Harris 1970; Wallamo *et al.* 1973; Jhala 1997). The daily forage intake (dry weight) was estimated from the number of bites taken by the focal lizard per day.

SIMSTAT Version 2.5 (Provalis Research 1995), SPSS Version 8.0 (SPSS 1997) statistical software and Arc View Version 3.2 and Arc View extensions (Animal Movement SA v 2.04 beta and Image Support, Geoprocessing and Spatial Analyst) (L30) GIS software (ESRI 1999) were used for analysis.

RESULTS

A significant linear relationship was obtained between log-transformed snout vent length and weight from 22 lizards (Fig. 1). The ratio of snout-vent lengths between male and female lizards was 1.09.

Density, spatial distribution and structure of burrow; population age structure

Spiny-tailed Lizards resided solitarily in burrows. Hatchlings resided with their mother during the initial days. Occasionally, they emerged from their mothers' burrows, foraged for short spans and returned swiftly; such explorations took place under the vigil of the mother. The density of burrows increased from 42.45/ha in summer to 66.04/ha in the monsoon, mainly due to new recruitment. The diameter of burrows was a good surrogate in determining the age of lizards residing in them (Fig. 2). Seasonal fluctuations were found in the age structure of the population (Fig. 3).

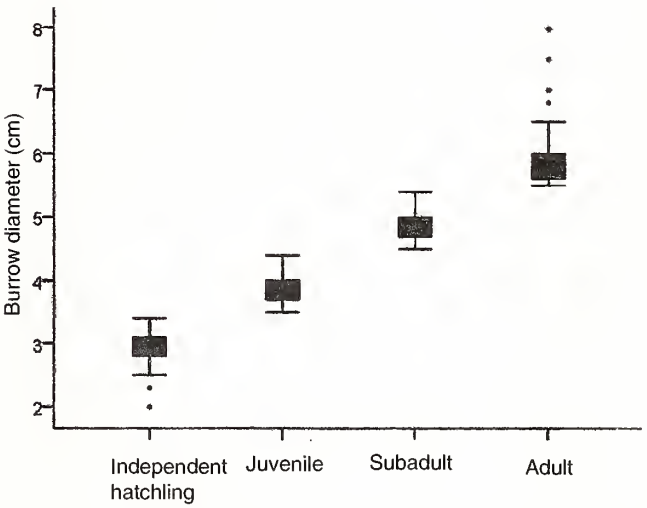

Fig. 2: Box plot of burrow diameters of various age categories of *Uromastyx hardwickii*

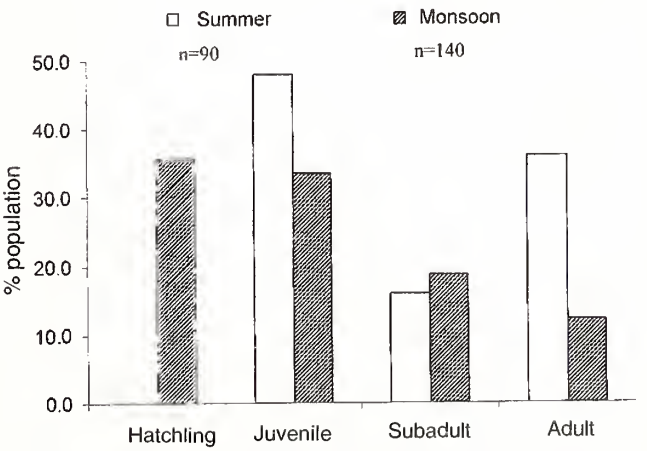

Fig. 3: Population structure of *Uromastyx hardwickii* in the study area as determined from burrow structures

An average, adult burrow, 1.2 m long (SE= 0.05, n=10), 0.5 meters deep (SE= 0.04) and 6.6 cm in diameter (SE= 0.3) comprised of three distinguishable segments. The tunnel ran straight down for about 0.7 m (SE =0.06) at an angle of 27° (SE =1.1) with the surface. Then it went down steeply for 0.5 m (SE= 0.05, n=6) at an angle of 28° (SE= 1.7). Sixty per cent of the burrows showed a change in trajectory between the two segments. The tunnel ended in a horizontal, box shaped chamber of size 17 cm (SE =1.8, n=7) (Fig. 4).

The spatial distribution of burrows analysed through nearest neighbour analysis (Rossbacher 1986) showed a clumping tendency (hatchlings: |Z|=13.27, r=0.019; juveniles: |Z|=12.87, r=0.018; sub adults: |Z|=9.62, r=0.14; adults: |Z|=7.57, r=0.011) (Fig. 5). But, there was no spatial affinity between adult and hatchling burrows (one tailed't' test: t=0.20, p=0.42).

Time budget and activity pattern of Spiny-tailed lizards

The Spiny-tailed lizards were strictly diurnal. Minimum activity was noticed during winter. The daily activities followed the following sequence. Emerging animals scanned their surroundings for conspecifics and predators; initially they basked flat near the burrow and later basked high on grass tussock. Gradually, they became fully active, moved, foraged and interacted. Group escape was a common anti-predatory behaviour. Re-emergence occurred only after the departure of the predator(s).

The maximum density of active lizards for a day was estimated to be 34/ha (SE =1.38, n=20 days) in summer and 28/ha (SE =4.44, n=20 days) in the monsoon. The animals remained active for 119 minutes (SE =12.13, n=25 lizards) or 8.3% of the day during summer and 93 minutes (SE =4.94, n=23 lizards) or 6.5% of the day during monsoon with basking constituting 16% (in summer, SE =1.42, n=25 lizards) and 37% (in monsoon, SE =1.6, n=23 lizards) of the daily activity duration and foraging constituting 55% (in summer, SE =2.7, n=25 lizards) and 41% (in monsoon, SE =2.0, n=23 lizards) of the daily activity duration (Fig. 6). There was no difference in activity duration between seasons (Mann Whitney U test; |Z|=0.26, p=0.80).

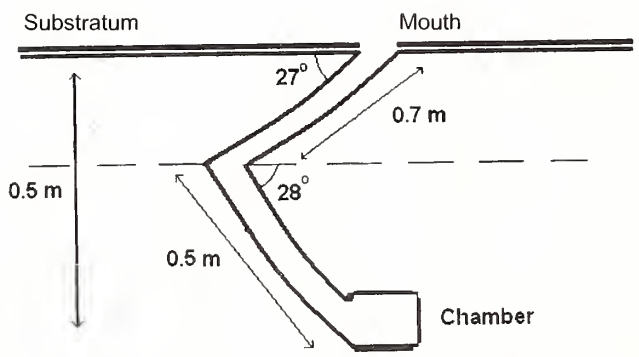

Fig. 4: Diagrammatic representation of a typical *Uromastyx hardwickii* burrow

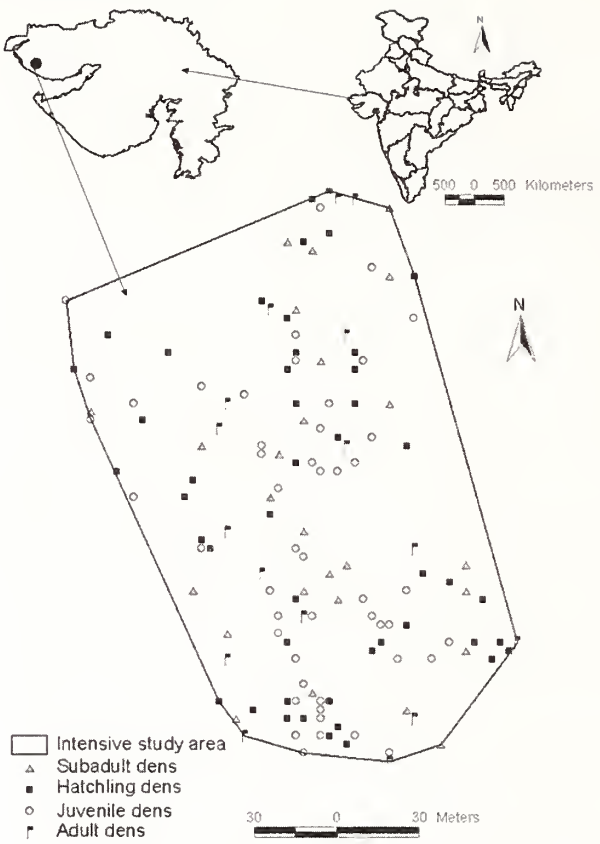

Fig. 5: Map of intensive study area showing the spatial distribution of *Uromastyx hardwickii* burrows along with geographical location of the study site

The activity pattern was bimodal in summer. Activity showed a major peak between 0900-1100 hrs and a minor peak around 1500 hrs. As the summer progressed, the major peak increased in height and the minor peak declined, although duration of activity remained unaltered. Bimodality changed to unimodality during the monsoon with the peak of activity between 1200-1500 hrs. In monsoon, activity pattern was highly unpredictable due to overcast skies (Fig. 7).

Temperature, activity and behavioural thermoregulation

The ground temperature ranged between 30 °C and 52 °C in summer and between 29 °C and 45 °C in the monsoon. The optimum near ground temperature for activity was 39 °C-41 °C. Larger lizards tended to be active within a narrow temperature range compared to smaller lizards (Fig. 8).

There was gradual and sequential replacement of body colours across the gradient of ambient and ground

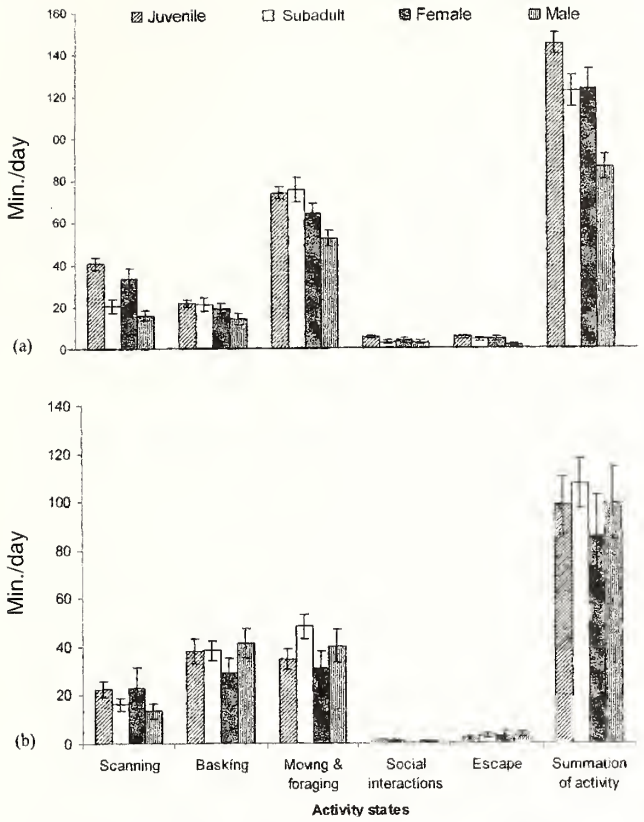

Fig. 6: Activity budget of various size classes of *Uromastyx hardwickii* during (a) summer, (b) monsoon. (Error bars are standard errors)

temperatures in summer, with darker pigments appearing at lower temperatures and lighter pigments at higher temperatures. Another behavioural feature associated with lighter pigmentations was arching of the tail to reduce body contact with ground (Fig. 9). During monsoons, the lizards

Table 1: Average percentage of home range overlaps among different size classes of *Uromastyx hardwickii*

		% Home range		
		Juvenile & subadult	Adult female	Adult male
		Area 95% fixed kernel		
Overlapped by	Juvenile and subadult	22 (5.7)	21 (6.0)	10 (5.3)
	Adult female	25 (1.9)	15 (11.8)	17 (12.9)
	Adult male	29 (5.9)	38 (18.8)	33 (8.8)
		Core 50% fixed kernel		
	Juvenile and subadult	5.4 (1.4)	1.6 (1.1)	3.3 (0.9)
	Adult female	2.6 (0.7)	0.6 (0.4)	3.1 (1.3)
	Adult male	7.5 (1.7)	8.4 (3.4)	7.3 (1.8)

Value in each cell represents the average percentage range area of the age-gender class in column, overlapped by the age-gender class in row. Standard Errors given in parentheses

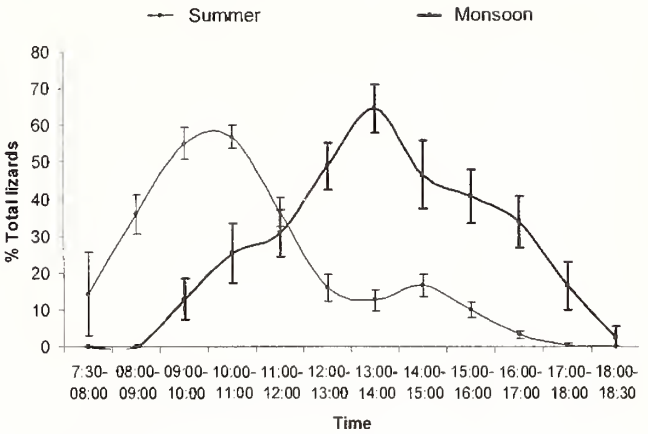

Fig. 7: Seasonal comparison of temporal patterns of active *Uromastyx hardwickii* (Error bars are 95% confidence intervals)

appeared much darker than in summer and retained a dark brown coloration throughout the day.

Movements and territoriality

The average estimated range size of the lizards in summer (2,332 sq. m, SE=384, n=23) was larger (t=4.59, $p<0.001$) than the average range in the monsoon (545 sq. m, SE =111, n=20). An average male home range was more than twice that of a female whereas the home range of adults and sub-adults was twice that of juveniles (Fig. 10). Home ranges showed extensive overlaps. The average overlap between adjacent ranges was 23% (SE =1.35, n=23) in summer and 11% (SE =3.65, n=20) in the monsoon, but the core area overlap was only 4.5% (SE =0.54, n=23) in summer and 0.5% (SE =0.29, n=20) in the monsoon. Overlaps were similar between the ranges of different ages and genders (χ^2=7.027, DF= 8, p= 0.534), but the extent of overlap varied seasonally

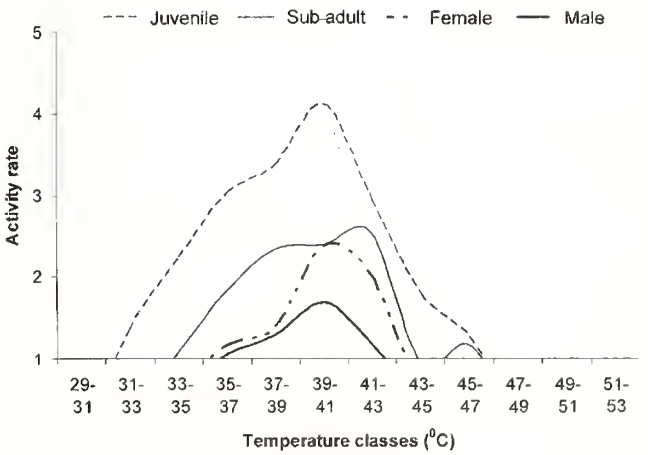

Fig. 8: Ground temperature preferences for activity of *Uromastyx hardwickii* determined as average lizard sightings at different temperatures

Table 2: Aggression encounter rates among different size classes of *Uromastyx hardwickii*

	Intensity	Adult male	Adult female	Juvenile and subadult	Hatchling
Adult male	Chase and display	0.3	0.1	0.1	0.0
	Fight	0.5	0.0	0.0	0.0
Adult female	Chase and display	0.1	0.5	1.9	0.0
	Fight	0.0	0.1	0.2	0.0
Juvenile and subadult	Chase and display	0.1	1.9	2.6	0.9
	Fight	0.0	0.2	1.0	0.0
Independent Hatchling	Chase and display	0.0	0.0	0.9	0.6
	fight	0.0	0.0	0.0	0.4

Frequency of occurrence of aggressive behaviour (chase and display or fight/sampling day/hectare) given in cells for each pair of age-gender classes

(ANOVA; F= 36.17, p= 0.009) (Table 1). Detailed analysis of five female home ranges showed that although an average male overlapped >20% to <40% of three female ranges (SE= 0.7) and >60% to <80% of only one female range (SE =0.6), there was high degree of variation among individual males (Fig. 11).

The lizards were much more aggressive during summer. Fights were common in the core areas and chases and displays were common, in the peripheries of home ranges (Fig. 12). The correlation between the extent of home range overlap

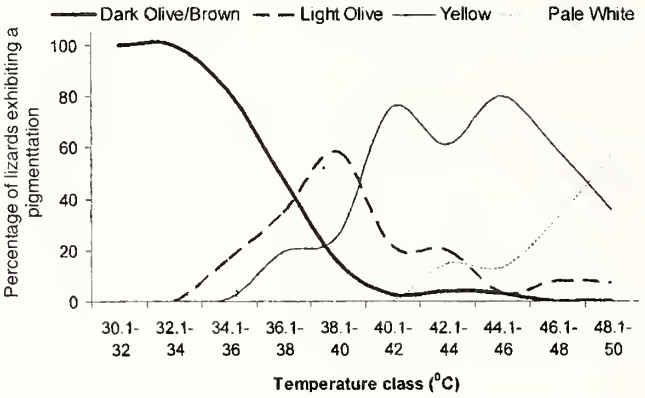

Fig. 9: Percentage of *Uromastyx hardwickii* showing various pigmentations at different ground temperatures during summer

and rate of aggressive encounters was insignificant (r=0.005, p=0.99). The maximum territorial aggressions were observed between juveniles and sub-adults followed by females and juveniles, mostly in the form of chase and displays. Males showed tolerance towards other classes and infrequent aggressions among each other, which mostly took the form of severe fights. Even independent hatchlings were aggressive towards each other (Table 2).

Foraging behaviour of Spiny-tailed lizards

The results obtained from bite count and faecal pellet analyses were similar. Spiny-tailed lizards were 'active foragers'. During summer, foraging was mainly restricted to morning. From bite counts, the lizard diet was found to have

Table 3: Seasonal food habits of *Uromastyx hardwickii* and seasonal food availability (no. of bites available/sq. m)

	Utilisation				Availability			
	Summer		Monsoon		Summer		Monsoon	
Food items	% bites	S.E.	% bites	S.E.	% bites	S.E.	% bites	S.E.
Chrysopogon	36.2	2.0	18.8	4.2	40.2	11.8	8.0	3.6
Cymbopogon	47.0	2.3	17.8	4.2	44.6	11.6	7.0	2.0
Aristida	0.0	0.0	2.0	0.7	0.0	0.0	1.6	1.2
Alternanthera	0.0	0.0	19.4	3.4	0.0	0.0	14.2	4.0
Anisomeles	0.0	0.0	7.3	1.6	0.0	0.0	5.0	2.3
Borreria	0.0	0.0	9.9	1.3	0.0	0.0	29.3	6.7
Euphorbia	0.0	0.0	6.6	1.6	0.0	0.0	6.3	1.9
Indigofera	0.0	0.0	8.6	1.6	0.0	0.0	7.5	2.6
Other herbs	0.0	0.0	1.4	0.5	0.0	0.0	20.7	6.7
Vernonia	0.0	0.0	2.6	1.6	0.0	0.0	0.6	0.6
Grewia	0.0	0.0	4.6	4.2	0.0	0.0	0.6	0.6
Clerodendron	6.5	1.2	0.0	0.0	6.9	6.9	0.7	0.7
Insects	10.3	2.1	0.8	0.5				

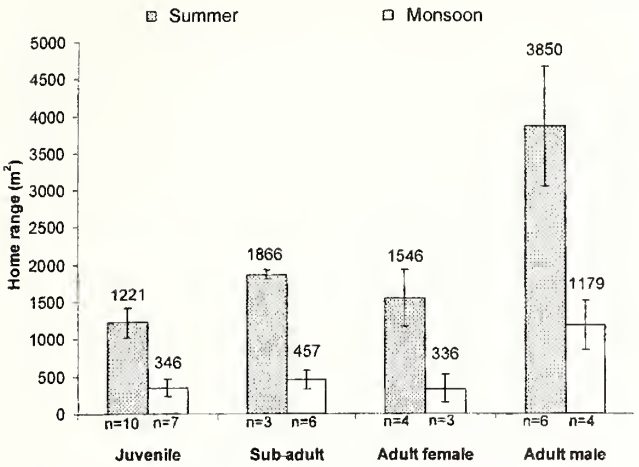

Fig. 10: Seasonal and intra-specific variations in home range size of *Uromastyx hardwickii* (Error bars are standard errors)

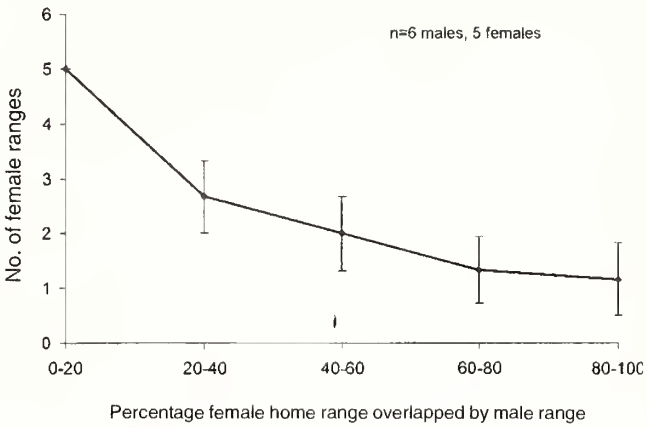

Fig. 11: Number of female ranges overlapped to various extents by an average male range (Error bars are standard errors)

grasses such as *Chrysopogon fulvus* and *Cymbopogon distans* (78% occurrence, SE =3.1, n=1892 bites), insects such as ants, termites and locusts (10% occurrence, SE =2.01), shrubs (6% occurrence, SE =1.16) and non-food items such as stones and sloughed skin. Food use was proportional to availability. The standardized niche breadth was 0.6.

In the monsoon, foraging took place throughout the day. Herbs (56% occurrence, SE=5.32, n=3486 bites) and grasses (40% occurrence, SE=8.03) constituted the major part of the diet. Shrubs (4% occurrence, SE =2.65) and insects (<1% occurrence, SE =0.48) were consumed less. Food use was not proportional to availability (χ^2=55.89, DF=10, p<0.0001). The scale of preference revealed by compositional analysis was:

Alternanthera > *Cymbopogon* > *Indigofera* > *Anisomeles* > *Chrysopogon* > *Borreria* > *Euphorbia* > *Aristida* > *Vernonia* > *Grewia* > *other herbs* (Table 3).

Herbs contributed 73% of the dry weight while grasses contributed only 24% and shrubs even less to the diet of the lizards in monsoon (Table 4). The forage intake (dry weight) was 4.1 gm / day (SE =0.4, n=16 days). Standardized niche breadth was 0.5. Proportion of the food items in the diet stabilized after 80 pellets were analysed (Fig. 13). The food availability varied greatly between seasons.

DISCUSSION

The survival strategies under conditions of extreme temperatures and low food availability revealed from this study hinted at the underlying 'trade-offs' that had to be made during the evolution of the species.

Excluding the quarter-year winter hibernation, the lizards could utilise barely two hours a day for daily activities as the flow was interrupted by frequent livestock grazing, predators and extreme thermal conditions. Associated with each activity were certain costs in terms of predation risk, overheating and/or energy expenditure and benefits in terms of energy gain and/or mating success. Coping with the time

Table 4: Biomass consumption of various food items by *Uromastyx hardwickii* during monsoon in Kutch

Food items	Bite counts	Percentage of bites in diet	Fresh weight/bite	Dry weight/bite	Dry weight in 100 bites	Per cent dry weight in diet
Chrysopogon	37	16.97	0.084	0.018	1.80	16.19
Cymbopogon	46	21.10	0.084	0.010	1.00	8.99
Anisomeles	14	6.42	0.100	0.023	2.33	20.98
Alternanthera	42	19.27	0.116	0.013	1.33	11.99
Borreria	22	10.09	0.103	0.015	1.50	13.49
Euphorbia	19	8.72	0.072	0.016	1.56	13.99
Indigofera	21	9.63	0.090	0.016	1.60	14.39
Others	17	7.80	—	—	—	—

Dry weights of simulated plant parts and percentage bites of each were used to obtain the percentage dry weight of each food item in the diet

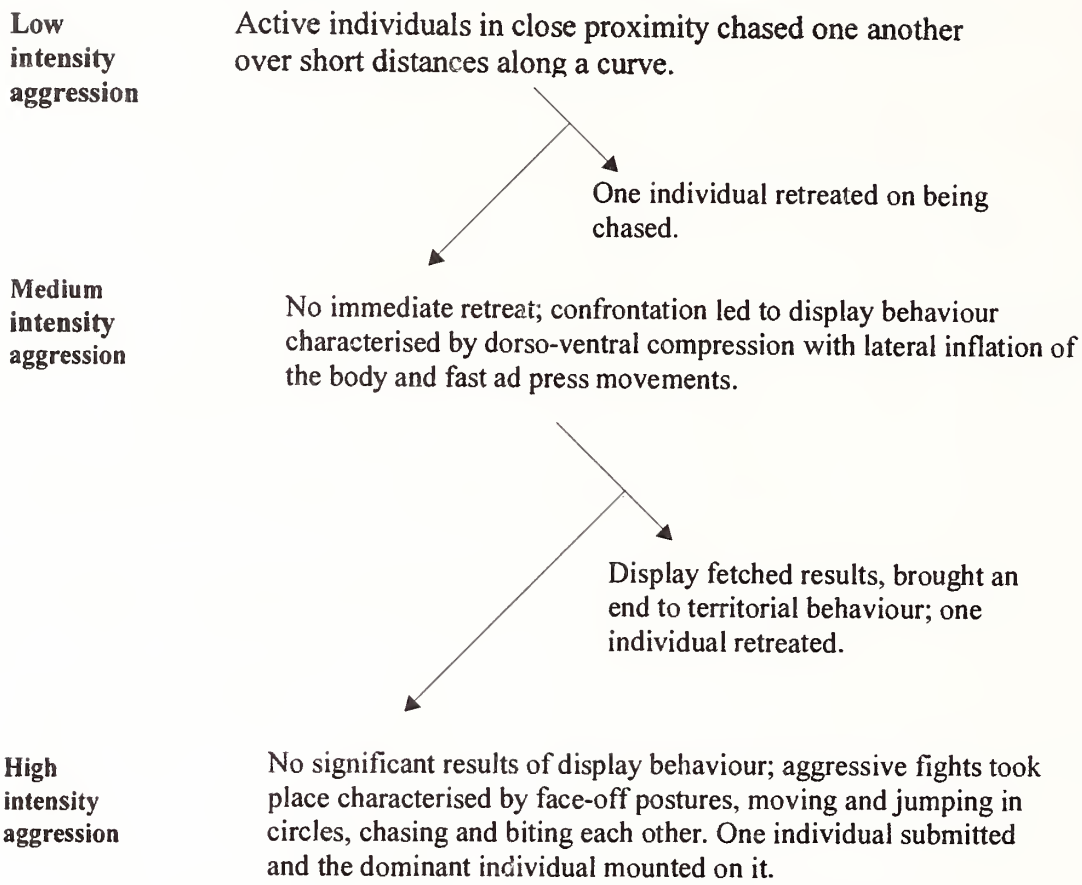
Low intensity aggression
Active individuals in close proximity chased one another over short distances along a curve.
One individual retreated on being chased.
Medium intensity aggression
No immediate retreat; confrontation led to display behaviour characterised by dorso-ventral compression with lateral inflation of the body and fast ad press movements.
Display fetched results, brought an end to territorial behaviour; one individual retreated.
High intensity aggression
No significant results of display behaviour; aggressive fights took place characterised by face-off postures, moving and jumping in circles, chasing and biting each other. One individual submitted and the dominant individual mounted on it.

Fig. 12: Sequential pattern of territorial aggression in *Uromastyx hardwickii*

constraint, involved time budgeting with trade-offs. The relative proportions of activities in the behavioural repertoire represented the evolutionarily optimised time allocation to maximize the net benefit and thereby, fitness. The metabolic rate per se (Bartholomew and Tucker 1964) would determine, among other things, the activity duration and foraging

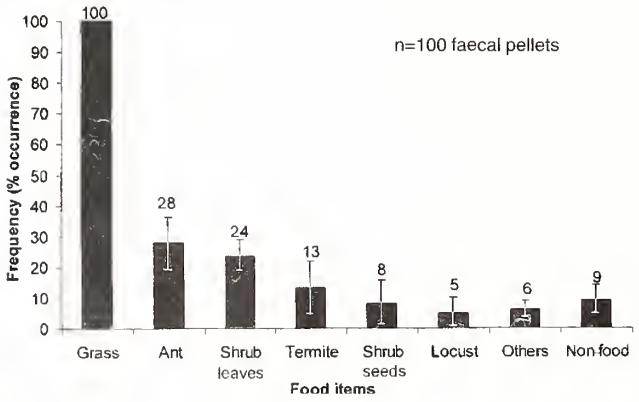

Fig. 13: Food habits of *Uromastyx hardwickii* during summer expressed as frequency of occurrence (percentage) of various food types from pellet analysis
(Error bars are bootstrap 95% confidence intervals)

behaviour of a species. Earlier studies associated a lower per body weight metabolic rate of large agamids (>300 gm) with a nutrition poor, herbivorous diet (Pough 1973) and reduced activity had always been a rule among herbivorous lizards (Andrews 1971; Iverson 1982); the probable reasons being a quick gut fill (Auffenberg 1979; Auth 1980), prolonged food passage time (Harlow *et al.* 1976; Iverson 1982) and temperature-dependent digestibility (Harlow *et al.* 1976; King 1996). A similar trend was observed in the congeneric *Uromastyx phylbi* (Zari 1996). The burrow mouths were kept open for a considerable time in the early morning, stimulating the animal to emerge, and blocked with loose soil on retreat. This maintained a thermal refuge for the lizards under temperature extremes and protected them from predators. Another anti-predatory strategy was the occasional bend seen in the burrows, probably in response to the burrow digging habit of some carnivores such as *Canis aureus*, *Vulpes bengalensis* and *Mellivora capensis*.

The combination of scarce resources and a severe environment provided minimal space to specialise. Consequently, the thermal niche use was generalised, naturally asking for thermoregulatory adaptation(s) in this

thermophilous ectotherm. Intermediate rests, reduced body contact during the hottest hours and efficient use of body pigmentation were the likely behavioural changes. Thermoregulatory use of pigmentation was also reported from *Moloch horridus* (Pianka *et al.* 1998). The relative rates of absorption and radiation vary with the pigmentation gradient, causing desert species to evolve a higher skin reflectivity (Hutchinson and Larimer 1960; Avery 1979). Smaller lizards had to utilize a larger temperature range for activity as the foraging efficiency increased with adulthood. Juveniles wasted considerable time in exploring resource clumps, and the smaller gape size associated with a small size was disadvantageous in handling food items such as dry grasses.

Continuous drought and livestock pressure reduced the grassland food abundance, supporting a generalised trophic niche use. Foraging theory suggested an optimal diet selection through successive addition of food items, ranked in terms of average food gain per unit handling time to maximise the net rate of food gain. Therefore, lower ranked foods would be deselected under higher food abundance, leading to specialisation (Pyke 1984). The results were in conformance with these predictions. During summer, there was a low density of dry grasses (*Chrysopogon*, *Cymbopogon*) and even lower densities of shrubs such as *Capparis decidua*, *Prosopis juliflora* and *Clerodendron*, of which only the latter was consumed. The monsoon brought forth a rich assemblage of herbs (*Borreria*, *Indigofera*, *Euphorbia*, *Anisomeles* and *Alternanthera*), succulent grass stocks and flowering shrubs (*Grewia*, *Vernonia* etc). Foraging was proportional to availability in the dry season but selective in the wet season, *Clerodendron* and insects were consumed only in summer, the latter for protein supplementation, a drought adaptation reported in committed herbivores (King 1996). An ontogenic, dietary shift from insectivory in juveniles to herbivory in adults, reported in this species by Minton (1966) was observed neither by Bhanotar and Bhatnagar (1977) nor in this study. Conducive environmental conditions were restricted to a short time span during which most of the lizards foraged avoiding spatial clumping. Such behavioural synchrony reduced conflicts and facilitated predator avoidance.

The field metabolic rate (Nagy 1982), estimated crudely from Nagy's relationship for iguanids (Nagy 1987), yielded a minimum required forage intake of 1.7 gm/day to maintain the energy balance. The observed feeding rate was more than twice this minimum requirement. Lizards compensated for the low food availability in the dry season with a surplus energy balance in the favourable season that would also be stored for hibernation. Similar trends were found in *Uromastyx aegyptius microlepis* (Robinson 1995). Moreover, the linear relation between the log-transformed body size and mass suggested that lizards tended to grow rapidly to adult size and then accumulate mass.

In a typical *Uromastyx* habitat, the benefit from extensive foraging movements in a large territory in terms of a higher food encounter rate would be less than the costs of predation risk, energy expenditure in movements and territorial defence. This might have caused movement restrictions to an intensive area, site fidelity at least for a year and reduced territoriality in the periphery of the home range, primarily to conserve energy. The observed range size (0.2 ha ± SE =0.04) was 10-fold less than predicted (2.5 ha) by Turner *et al.* (1969). Male home ranges, however were much larger, a common feature in lizard ecology (Ferner 1974). The monsoon had reduced spatial use under the relative abundance of food, higher predation risks from Jackal, domestic dogs, Fox, raptors and cattle egrets, a smaller need of searching for mates and a greater need for conserving energy before entering the hibernation phase.

Resource dispersion caused the lizards to burrow in weak clumps. Hatchlings residing in maternal burrows during the initial 29 to 40 days of hatching, utilised a range of 6 to 12 m from their burrows, and were tolerated by adults (Bhanotar and Bhatnagar 1977). Burrows, generally located at the centre of core ranges, were also the centre of territoriality that started right after independent burrowing. Intraspecific competition for establishment of resource territories was high among juveniles. Juveniles were commonly found fighting for burrow acquisition that was followed by acquisition of territory. The extent of overlap between adjacent home ranges of two age-gender classes depended on their relative movements. Overlaps were minimal in the core, where a resident individual usually fought off an intruder. They were extensive in the fringes where confrontations were mostly mitigated through subtle aggressions. Such patterns were suggestive of territoriality in the core, but temporally determined resource sharing in the periphery of the home range. Previous studies reported hierarchy, territoriality (Stamps 1977; Heatwole and Taylor 1987) and mixed social interactions elicited by overcrowding (Hunsaker and Burrage 1969) that might have resulted here from spatial clumping of resources and burrowing substrate. Males showed relatively low aggression rates. Male-juvenile, male-female and male-male core range overlaps were similar during the study period. Thus, resource territoriality predominated over reproductive territoriality in this species. However, we had no observation of breeding as the study period included only a minor portion of the mating period. Hence, there is likelihood of resource based territories changing to breeding territories during the peak mating period. The core range of each male overlapped with one or two

(sometimes exclusive) female ranges. The affinities of female(s) towards specific males caused high variability in inter-female range overlaps. This confirmed certain minimum reproductive chances for each male. But, entire ranges of some included even more females indicating that individuals differed in their reproductive strategies. Benefiting out of a high average longevity, some males probably postponed their surplus mating potential by minimising exploratory movements, to use the conserved energy later. Others possibly attempted opportunistic mating through energy-costly explorations. As the reproductive season coincided with the lean food availability period, such differences in mating strategies were of high evolutionary significance, and explained the wide variation in male range size.

Juxtaposing the livelihood strategy of this non-nomadic, generalised herbivore, avoiding predators through escape, against the nomadic, highly specialised insectivore *Moloch horridus* that freezes to avoid predators (Pianka *et al.* 1998) strikingly exemplifies the alternative evolution of correlated life history components.

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PREDATORS OF NON-PENAEID PRAWNS OF MUMBAI COAST[1]

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Non-penaeid prawns, *Acetes* spp., *Nematopalaemon tenuipes* and *Exhippolysmata ensirostris* were found to be important forage organisms of fishes occurring along the Mumbai coast. Their predators have been enlisted from the investigations carried out by various workers in the region and degree of their predation quantified. Of the 79 species of commercially important fishes, cephalopods and crustaceans, 97.4% predated on non-penaeid prawns. *Acetes* spp. was the food of 92.4%, *N. tenuipes* of 34.2% and *E. ensirostris* of 21.5% fishes. As these prawns support pelagic as well as demersal fisheries of commercial importance in the region, a detailed investigations of their prey-predator relationship may enable us to understand the effects of exploitation of prey organisms on predators.

Key words: Non-penaeid prawns, food, predators, commercial fisheries, Mumbai coast, prey-predator relationship

INTRODUCTION

Crustaceans are one of the most important groups of organisms, particularly for fishes. Many fishes, whether benthophagous, planktophagous, carnivorous or herbivorous pass through a phase in their development when they use planktonic crustaceans as food (Nikolsky 1963). Among crustaceans, prawns are widely preyed upon owing to their relatively smaller size and less defensive body structures. Besides, being benthic in nature, they are predated by a majority of demersal fishes in the tropical coastal waters.

The marine non-penaeid prawns comprising of the tiny epipelagic, sergestid shrimp *Acetes* spp., the palaemonid prawn *Nematopalaemon tenuipes* and the hippolytid prawn *Exhippolysmata ensirostris* constitute a commercially important fishery along the north-west coast of India. The average annual production of non-penaeid prawns is 46,990 tonnes and contributes to 16.4% of the total marine fish landings of Maharashtra. Non-penaeid prawns form fisheries of commercial importance only along north-west coast of India, including Gujarat, therefore it is characteristic (Deshmukh 1993). Being smaller in size and abundant in the coastal waters, they are also the prime forage organisms for the coastal fishes of this region.

Although there are several investigations on the food and feeding habits of a large number of marine fishes and other organisms of commercial importance in the coastal waters of Mumbai, there is no account that enumerates predators of the forage organisms. The present investigation, therefore, not only lists the predators of the non-penaeid prawns in the region, but also attempts to signify their importance in the marine economy along the coast of Mumbai.

METHODS

The degree of predation reported by various investigators as 'mostly', 'moderately', 'sometimes' and 'occasionally' has been quantified by assigning them ++++, +++, ++ and + signs respectively and negative predation by the – sign for the three species of non-penaeid prawns, namely *Acetes* spp. *Nematopalaemon tenuipes* and *Exhippolysmata ensirostris* (Table 1).

RESULTS AND DISCUSSION

Table 1 enumerates the predators and their degree of predation on the non-penaeid prawns in Mumbai waters. Of the 79 fish species investigated by various workers for their food and feeding habits in Mumbai waters, 77 (97.5%) are predators of the non-penaeid prawns. Only two species, *Cynoglossus macrolepidotus* (Rao and Dwivedi 1989) and *Tripanchen vagina* (Kulkarni 1976) have not been reported to feed on these prawns. *Acetes* spp. are predated by 73 (92.4%) species, *N. tenuipes* by 27 species (34.2%) and *E. ensirostris* by 17 (21.5%) species of fishes.

In the case of *Acetes* spp. 5.1% fishes consumed them 'mostly', 22.8% 'moderately', 34.2% 'sometimes' and 30.4% 'occasionally'; 7.6% fishes have not been reported to feed on it. Such high predation on *Acetes* spp. by the juveniles and adults of most fishes may be attributed to the small size and delicate, translucent, and defenceless body of the prey. *Acetes* spp. is also devoid of a strong rostrum and hard calcareous shell. The gregarious swarming habit of the species in coastal waters perhaps enables the predators to devour it in large quantity.

Table 1: Predators and their degree of feeding on non-penaeid prawns in Mumbai waters

S.No.	Name of predator	Extent of predation on			Remarks	Reference
		Acetes spp.	*N. tenuipes*	*E. ensirostris*		
1.	*Engraulis hamiltoni*	++	—	—	Feeds mainly on prawn larvae and *Acetes*	Bapat, 1948.
2.	*Engraulis purava*	+++	—	—	Adults feed mainly on *Acetes* spp.	Bapat and Bal, 1952.
3.	*Engraulis dussumieri*	++	—	—	quantity of prawns in majority	_____ ,, _____
4.	*Engraulis commersonius*	+	—	—	Feeds mainly on prawn larvae	_____ ,, _____
5.	*Coilia dussumieri*	+	—	—	Occasionally feeds on *Acetes* spp.	Bapat and Bal, 1952; Fernandez, 1986.
6.	*Clupea toli*	+	—	—	Crustacean food increases with the size of fish	_____ ,, _____
7.	*Kovala coval*	+	—	—	Feeds on crustacean larvae	Koshey, 1996.
8.	*Clupea brachysoma*	+	—	—	Prawn larvae form 8-10% of food	Bapat and Bal, 1952.
9.	*Pellona elongata*	+	—	—	*Acetes* forms 44% of food	_____ ,, _____
10.	*Pellona motius*	+	—	—	% of prawns is 12-15	_____ ,, _____
11.	*Pellona filigera*	+++	—	—	Juveniles have 15% of food with prawn larvae but adults mainly feed on *Acetes* and other pelagic crustaceans	Bapat,1948; Meenakshisundaram and Marathe, 1962; Suseelan and Nair, 1969.
12.	*Thryssa malabarica*	++	—	—	Crustaceans form the major food which includes *Acetes*	Pawar, 1994.
13.	*Ilisha filigera*	++++	—	—	Bulk of the food is constituted by a single item namely, *Acetes*	Johnson, 1992.
14.	*Chirocentrus dorab*	++	—	—	Next to fish crustaceans are important in the diet in which *Acetes* is dominant	Pawar, 1992.
15.	*Harpadon nehereus*	++++	+++	+	Juveniles and adults mainly feed on *Acetes* and non-penaeid prawns	Bapat, 1959, 1970.
16.	*Polynemus indicus*	++	++	+	Adults feed on *N. tenuipes*, but juveniles on *Acetes*	Karekar, 1954.
17.	*Polynemus tetradactylus*	++	+	+	About 48-52% food of juveniles is of crustacean origin	Bapat and Bal, 1952.
18.	*Polynemus heptadactylus*	+++	++	++	*Acetes* is the food of juveniles but *N. tenuipes* and *E. ensirostris* are eaten by adults	Nayak, 1965; Ivan, 1987.
19.	*Saurida tumbil*	++	++	+	*Acetes* and *N. tenuipes* form considerable quantity of food	Dighe, 1977.
20.	*Pomadasys hasta*	+	+	+	Crustacean food is relatively less but in some months it formed the entire diet	Suseelan and Nair, 1969; Deshmukh, 1973.
21.	*Nemipterus japonicus*	+++	+	—	Out of crustaceans, *Acetes* is the most favoured food items in all stages of maturity	Acharya, 1980.
22.	*Nemipterus mesoprion*	++	+	—	_____ ,, _____	Chakraborty pers. comm.

Table 1: Predators and their degree of feeding on non-penaeid prawns in Mumbai waters (*contd.*)

S.No.	Name of predator	Extent of predation on			Remarks	Reference
		Acetes spp.	*N. tenuipes*	*E. ensirostris*		
23.	*Nemipterus delogae*	++	+	—	_____ ,, _____	_____ ,, _____
24.	*Pseudosciaena diacanthus*	—	++	+	Prawns including *N. tenuipes* and *E. ensirostris* are important next to fish diet	Bhatt *et al.* 1964; Rao, 1964; Suseelan and Nair, 1969.
25.	*Sciaenoides brunneus*	+	++	+	Juveniles feed on all species of non-penaeid prawns but adults take penaeids and *N. tenuipes*	Kutty, 1967; Suseelan and Nair,1969; Jayaprakash, 1974.
26.	*Otolithus ruber*	+++	+++	—	Crustaceans form 58% of the diet; *Acetes* and *N. tenuipes* are important food items	Vaidya, 1960; Suseelan and Nair, 1969.
27.	*Otolithus cuvieri*	++	—	—	Bulk of the food is formed of crustaceans, in which *Acetes* contributes major percentage	Gulati, 1987.
28.	*Otolithus argenteus*	+++	—	—	Mainly subsists on fishes and crustaceans in which *Acetes* is common	Basrur, 1975.
29.	*Johnius dussumieri*	+	+	+	*Acetes* and other prawns form a considerable part of diet	Bapat and Bal, 1952; Sawant, 1963; Suseelan and Nair, 1969.
30.	*Johnius carutta*	++	+	—	Free living crustaceans and *Acetes* form the main food	Chakraborty, 1988
31.	*Johnius vogleri*	+++	-	++	*Acetes* is one of the major food items	_____ ,, _____
32.	*Johnius macrorhynus*	++	+	+	*Acetes* is one of the major food items	_____ ,, _____
33.	*Johnius sina*	++	—	—	*Acetes* is moderately fed	Dukhande, 1991.
34.	*Johnius glaucus*	+++	—	—	*Acetes* prevailed in the gut in all the months and formed the major food	Wasnik, 1994.
35.	*Megalaspis cordyla*	+++	—	—	*Acetes* is one of the major food items	Datar, 1954; Bapat *et al.* 1982; Shendye, 1994.
36.	*Atropus atropus*	+++	—	—	Crustaceans form the major diet with *Acetes* forming the bulk	Kochar, 1988.
37.	*Carangoides malabaricus*	++	—	—	The crustaceans varied from 42-80% in the food and *Acetes* formed the favourite diet	Kochar, 1988.
38.	*Chorinemus toloo*	+	+	+	Young ones feed on small prawns	Bapat, 1948.
39.	*Decapterus russellii*	+++	—	—	*Acetes* is the major food item with ponderal index of 37.62%	Tamhane, 1999.
40.	*Decapterus dayii*	+++	—	—	*Acetes* is one of the major food items	Raje, pers. comm.
41.	*Allepes djedaba*	+++	—	—	*Acetes* is the major food item	Raje, 1993.

Table 1: Predators and their degree of feeding on non-penaeid prawns in Mumbai waters (*contd.*)

S.No.	Name of predator	Extent of predation on			Remarks	Reference
		Acetes spp.	*N. tenuipes*	*E. ensirostris*		
42.	*Rastrelliger kanagurta*	++	—	—	*A. indicus* was found in large numbers in the gut in October	Bapat *et al.* 1982; Shendye, 1994.
43.	*Trichiururs lepturus*	++	+	+	Non-penaeid prawns form the major food item	Chakraborty, pers. comm.
44.	*Lepturacanthus savala*	++	+	—	In the gut *Acetes* is dominant during January and October	Rizvi, 2001.
45.	*Eupluerogrammus muticus*	++++	+	—	*Acetes* is a prominent food during February-May and November-December	Rizvi, 2001.
46.	*Muraenosox talabonoides*	+	+	+	Highly carnivorous, and its juveniles feed on crustaceans and prawns	Mohamed, 1955; Suseelan and Nair,1969
47.	*Arius thalassinus*	+	—	—	Though a benthic feeder, consumes significant quantity of prawns including *Acetes*	Suseelan and Nair,1969; Rane, 1996.
48.	*Arius dussumieri*	+	—	—	Canivorous bottom feeder, stomach shows *Acetes*	_____ ,, _____
49.	*Arius sona*	+	—	—	Prawns form 18% of the diet	Singh, 1965.
50.	*Arius jella*	+	—	—	Food consists of some crustaceans and prawns	Suseelan and Nair,1969
51.	*Arius maculatus*	+++	—	—	*Acetes* is a common food item, sometimes stomach is gorged with it in older fish	Roy, 1979.
52.	*Osteogeneiosus militaris*	+	—	—	Consumes considerable quantity of non-penaeid prawns	Raje, pers. comm.
53.	*Begmaceros macclellandi*	++	—	—	*Acetes* and prawn larvae form the bulk of the food	Bapat, 1948; Parulekar, 1964.
54.	*Mugil parsia*	+	—	—	3.33% of food is *Acetes*	Bapat, 1948.
55.	*Cynoglossus macrolepidotus*	—	—	—	Non-penaeid prawns not observed in the gut	Rao and Dwivedi, 1989.
56.	*Apogon bendansis*	++	—	—	50% food is *Acetes*	Bapat, 1948.
57.	*Apogon wassinki*	+	—	—	Food consists of small crustaceans and *Acetes*	Bapat, 1948.
58.	*Lactarius lactarius*	+++	—	—	Mainly feeds on fishes and Crustaceans but *Acetes* is the favourite food	Choudhary, 1978.
59.	*Pampus argenteus*	++	—	—	Presence of *Acetes* in stomachs of young pomferts suggests they are major food item	Rege and Bal, 1963.
60.	*Equula indicator*	++	—	—	Feeds on small prawns and their larvae	Bapat, 1948.
61.	*Tripauchen vagina*	—	—	—	Stomach contents did not show presence of non-penaeid prawns	Kulkarni, 1976.

Table 1: Predators and their degree of feeding on non-penaeid prawns in Mumbai waters (*contd.*)

S.No.	Name of predator	Extent of predation on			Remarks	Reference
		Acetes spp.	*N. tenuipes*	*E. ensirostris*		
62.	*Scoliodon laticaudus*	+	+	+	Among the prawn species in the diet, all three non-penaeids were identified	Mathew, 1992.
63.	*Dasyatis sephen*	+	++	+	The three non-penaeid prawns were consumed fairly	Raje, 2003.
64.	*Dasyatis uarnak*	—	+	—	*N. tenuipes* had fair occurrence in the stomach	_____ ,, _____
65.	*Trygon walga*	—	++	—	_____ ,, _____	_____ ,, _____
66.	*Gymnura macrura*	—	++	—	_____ ,, _____	_____ ,, _____
67.	*Loligo duvauceli*	++	+	+	Small non-penaeid prawns constitute the major food	Kuber, 1987.
68.	*Sepia aculeata*	+	+	—	Small non-penaeid prawns constitute the major food	Kuber, pers. comm.
69.	*Charibdys cruciata*	+	—	—	Occasionally feeds on *Acetes*	Deshmukh, unpublished data.
70.	*Metapenaeus affinis*	++	—	—	Proportion of *Acetes* in diet increases from Nov-March, and in May it is exclusive in the diet	Mehendale, 1959.
71.	*Metapenaeus brevicornis*	+++	—	—	In adults *Acetes* is the major food item	Kathuria, 1967.
72.	*Parapeneopsis sculptilis*	+++	—	—	Foregut is mostly full of *Acetes*	Kathuria, 1967; Aravindakshan, 1979.
73.	*Parapeneopsis hardwickii*	++	—	—	*Acetes* forms exclusive diet	Kathuria, 1967.
74.	*Parapeneopsis stylifera*	+	—	—	Occasionally feeds on *Acetes* in some months	Kathuria, 1967.
75.	*Solenocera crassicornis*	++++	—	—	*Acetes* is the major diet	Kathuria, 1967; Kunju, 1967.
76.	*Penaeus japonicus*	++	—	—	Occasionally *Acetes* is seen in the stomach	Kathuria, 1967.
77.	*Penaeus merguiensis*	++	—	—	Occasionally *Acetes* is seen in the stomach	Kathuria, 1967.
78.	*Nematopalaemon tenuipes*	++	—	—	Occasionally *Acetes* is seen in the stomach	Kunju, 1979; Deshmukh, 1988
79.	*Exhippolysmata ensirostris*	+++	—	—	*Acetes* is the most common food item	Deshmukh, 1988.

N. tenuipes was found to be predated 'moderately' by 2.5% 'sometimes' by 11.4%, and 'occasionally' by 22.8% fishes. This species also has a relatively small and defenceless body structure without a hard calcareous exoskeleton. Long spider leg-like pereopods enable it to lead a pelagic life, but without strong swimming ability, which makes it an easy prey for predators. *E. ensirostris* is, however, taken only 'sometimes' by 2.5% fishes and 'occasionally' by 19% fishes. It possesses a relatively hard exoskeleton and a long, acutely pointed, serrated rostrum, which being an organ of offence, perhaps makes it less vulnerable to predation.

Bapat (1948), and Bapat and Bal (1952) investigated food habits of young ones of 26 species of fishes occurring in coastal waters off Bombay (= Mumbai), and commented

that prawn larvae and *Acetes* spp. were their major food items. These fishes included pelagic clupeids such as *Engraulis hamiltoni*, *E. dussumieri*, *E. purava*, *E. commersonianus*, *Stolephorus commersoni*, *Coilia dussumieri*, *Pellona filigera*, *P. brachysoma*, *P. elongata*, *P. motius* and *Clupea toil.*

Bapat (1959, 1970) studied details of the food habits of Bombay Duck *Harpadon nehereus*, an important carnivore, forming a major pelagic fishery along the north-west coast of India. It is the major predator of non-penaeid prawns, which in certain months of the year feeds entirely on *A. indicus*. But during April-May and August-September it consumes a good quantity of *N. tenuipes* in addition to *A. indicus*. The fish also consumes considerable quantity of *E. ensirostris*. Among the non-penaeid prawns, *Acetes* spp. is the most favourite food of Bombay Duck. Pillai (1980) attempted to correlate the abundance of Bombay Duck with its prey. He suggested that in the inshore waters of Bombay, where Bombay Duck is abundant, the catches of *Acetes* are low on account of heavy feeding by the Bombay Duck. Devaraj (1987) postulated that since the sergestid shrimp *Acetes* spp. are the main food of Bombay Duck, the discontinuous distribution of the species along the north-west and north-east coasts of India is primarily due to the enormous biomass of these shrimps, which feed on the large quantity of detritus produced by the load of domestic sewage generated by the metropolitan cities of Bombay (=Mumbai) and Calcutta (= Kolkata), located on the two coasts respectively.

Food of most of the important pelagic fishes occurring in the coastal waters also consists of *Acetes* spp. as reported by Suseelan and Nair (1969) for *Ilisha filigera*, Bapat *et al.* (1982) and Shendye (1994) for *Megalaspis cordyla*, Chakraborty (pers. comm.) for *Truchiurus lepturus* and Rizvi (2001) in the case of Ribbon Fishes *Lepturacanthus savala* and *Eupluerogrammus muticus*. The Indian Mackerel *Rastrelliger kanagurta* is a planktivore, feeding on phytoplankton in early stages and zooplankton in later life, but Bapat *et al.* (1982) reported that its shoals occurring along the north-west coast were found to have *Acetes* spp. in their stomach. Similarly, the golden anchovy *Coilia dussumieri* forms an important pelagic fishery along the north-west coast, but the fish grazes mainly on the zooplankton and crustacean larvae, including *Acetes* spp. (Fernandez 1986). In the case of Silver Pomfret *Pampus argenteus*, which forms a lucrative fishery around Mumbai, Rege and Bal (1963) have stated that small shrimps belonging to the genus *Acetes* were found in the toothed pharyngeal pouches of the juveniles, suggesting possibility of these shrimps forming one of the major food item of young ones of fish. In the case of carangid fishes, Kochar (1988) reported that *Atropus atropus* and *Carangoides malabaricus* have crustacean diet, in which they constituted as much as 89.5% in certain months and *Acetes* was the favourite food. Similarly, *Decapterus russelli* (Tamhane 1996) and *A.djedaba* (Raje 1993) also prey upon *Acetes* spp. with a high index of preponderance.

Some of the dominant perches, *Nemipterus japonicus* (Acharya 1980), *N. mesoprion* (Chakraborty pers. comm.) and *Pomadasys hasta* (Suseelan and Nair 1969; Deshmukh 1973) also have *Acetes* spp. as one of their occasional food items. The young of threadfin fishes, such as *Polynemus indicus*, *P. tetradactylus* and *P. heptadactylus* (Bapat 1948; Karekar 1954; Karekar and Bal 1958; Nayak 1965; Kagwade 1970), have a crustacean diet with *Acetes* spp. constituting the important forage organisms.

It is obvious to find the pelagic fishes of this coast feeding on the non-penaeid prawns, which themselves are pelagic, but several studies indicate that even demersal fishes prey upon these prawns. Suseelan and Nair (1969) investigated food habits of 17 species of demersal fishes from Bombay waters and commented that prawns, in general, and *Acetes indicus*, in particular, were the common food item at the top of the food index.

Sciaenids are perhaps the most common demersal fishes in the coastal waters of Mumbai and their food mainly consists of non-penaeid prawns. 'Ghol' (*Pseudosciaena diacanthus*) and 'Koth' (*Sciaenoides brunneus*) are the largest sciaenids, which form characteristic fisheries in the region. Rao (1963) and Bhatt *et al.* (1964) reported that adults of 'Ghol' and 'Koth' feed mainly on fishes in addition to penaeid and non-penaeid prawns, which include *A. indicus*, *N. tenuipes* and *E. ensirostris,* but Bapat and Bal (1952) and Jayaprakash (1974) found that their young mainly feed on *Acetes* spp. The lesser sciaenids such as *Johnius dussumieri* (Bapat and Bal 1952; Savant 1963; Suseelan and Nair 1969), *J. vogleri*, *Otolithus cuvieri*, *Johnius macrorhynus* (Chakraborty 1988), *J. sina* (Dukhande 1991) and *J. glaucus* (Wasnik 1994) also feed mainly on *Acetes* spp. Vaidya (1960), Suseelan and Nair (1969), and Gulati (1987) showed that bulk of the food of *Otolithus cuvieri* is constituted by crustaceans, in which *Acetes* spp. form a major percentage. Similarly, Basu (1975) found that *O. argenteus* subsists mainly on crustaceans and fishes and rarely on other organisms. He remarked that *Acetes* spp. and squilla (*Stomatopoda*) are the common food items, in addition to *Leander tenuipes* (= *N. tenuipes*) and *E. ensirostris*. He further states that crustaceans are the major food in smaller length groups as compared to the larger ones and in relation to maturity stages, crustaceans dominate in all maturity stages and *Acetes* is the most favoured food.

The highly carnivorous Conger Eel *Muraenesox talabonoides* feeds, besides many fishes, on the non-penaeid prawns (Mohamed 1955). Similarly, catfishes *Arius sona*

(Singh 1965), *A. jella* and *A. dussumieri* (Suseelan and Nair 1969) and *Arius thallassinus* (Rane 1996), though predominantly benthic feeders, consume considerable quantity of prawns, including the three species of non-penaeid prawns. Roy (1979) reported that in catfish *Arius maculates*, *Acetes* spp. was the common food item during most months in older fishes, and sometimes their stomachs were gorged with *Acetes* spp..

Among the elasmobranchs, the Shark *Scoliodon laticaudus* feeds on non-penaeid prawns among which *Acetes* spp. is the common food item, found throughout the year with the index of preponderance varying from 0.004 in March to 15.44 in September (Mathew 1992). Four species of rays, *Dasyatis sephen*, *D. uarnak*, *Trygon walga* and *Gymnura macrura* fed on non-penaeid prawns, among which *N. tenuipes* was the common food item (Raje 2003).

Among the highly demersal fishes, the Tongue Sole *Cynoglossus macrolepidotus* feeds on benthic crustaceans (Rao and Dwivedi 1989), and none of the non-penaeids are reported to form its diet. The gut contents of *Tripauchen vagina*, a common gobid fish occurring in the coastal waters of Mumbai, also did not show presence of any of the non-penaeid prawns (Kulkarni 1976).

Of the invertebrate predators of non-penaeid prawns, Kuber (1987) noted that the cephalopods, *Loligo duvauceli* and *Sepia aculeata* feed on non-penaeid prawns and sometimes their mantle cavity is full with *Acetes* spp. Deshmukh (unpublished data) found that the stomach of the pelagic marine crab *Charybdis cruciata* is occasionally gorged with *Acetes* spp. The works on the food and feeding habits of some of the penaeid prawns of the region, Mehendale (1959): *Metapenaeus affinis*, Kathuria (1967): *M. brevicornis*, Kunju (1967): *Solenocera indicus* (= *S. crassicornis*) and Aravindakshan (1979): *Parapeneopsis sculptilis* have shown that *Acetes* spp. is their major food item, and their foreguts invariably show entire specimens of *Acetes* spp.. The food habits of non-penaeid prawns, *N. tenuipes* and *E. ensirostris* (Deshmukh 1988) revealed that the *N. tenuipes* feeds on *Acetes* spp. occasionally, while *E. ensirostris* feeds on it voraciously.

It is seen from the foregoing account on feeding habits of majority of pelagic and demersal fishes, cephalopods and crustaceans that the non-penaeid prawns form one of their most important food items in general, but their young ones feed on *Acetes* spp. in particular. Investigations on the food habits of other fishes may reveal that they too may be feeding on non-penaeid prawns. Thus, non-penaeid prawns form the single most important group of forage organisms preyed upon by a vast majority of fishes in the coastal waters, of Mumbai. They play a far greater role in the marine economy of the coastal waters and must be responsible for supporting the huge biomass of economically important fisheries of Bombay Duck, sciaenids, polynemids, carangids, cephalopods and the penaeid prawns of the region.

Thorson (1960) reviewed the feeding habits and food requirements of predatory fishes in north-eastern Atlantic and commented that fishes in temperate waters consume on an average food 5-6% of their own living weight per day. He further added that invertebrate predators are extremely predaceous, and consume food corresponding to about 25% of their living weight per day. If the same were true for the tropical waters, then the biomass of non-penaeid prawns would be far greater than what is exploited along the coast of Mumbai. A detailed quantitative analysis of predation of the species of fishes and other marine organisms of commercial importance, which play a vital role in the food web of the coastal water, would therefore, help in understanding the complexities of predator-prey relationships. This may, in future, enable us to know feeding movements, seasonal abundance, and fluctuations in catches of the commercially important coastal fishes.

The 'dol' net fishery along the Maharashtra coast (Deshmukh 1993) and the Saurashtra coast of Gujarat (Khan 1986) exploits non-penaeid prawns (i.e. prey organisms) on a large scale. But, the catch consists mostly of tiny *Acetes* spp., which soon after catching turns into a semi-decomposed paste (Deshmukh 1993). However, the catch is either used as manure or reduced to fish-meal, from which economic returns to the fishermen are very poor. Despite this, exploitation of *Acetes* spp. on an enormous scale by trawlers in Gujarat state in recent years (CMFRI 1997) has caused serious concern, as to whether it would adversely affect the production of predators (i.e., commercially important fishes) from that region. It is apparent that on account of their low commercial value, but great significance in the marine food web, the exploitation of non-penaeid prawns on a large scale would not be advisable. However, in-depth study of the predator-prey relationship of the non-penaeid prawns should be taken up immediately to understand species interactions for the management of the important fisheries of the entire Gujarat-Maharashtra region. This can throw some light not only on the impact of exploitation of the non-penaeid prawns, but also on the abundance and fluctuations of the commercially important fishes.

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HEPATICS AND ANTHOCEROTES (BRYOPHYTA) OF TAMIA AND PATALKOT VALLEY (DISTRICT CHHINDWARA), MADHYA PRADESH[1]

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Observations and enumeration of liverworts and hornworts of Tamia hills and Patalkot valley have been made for the first time. Eighteen taxa belonging to orders Jungermanniales, Metzgeriales, Marchantiales and class Anthocerotae have been reported to occur in this valley. *Lophozia mayebarae* (Hatt.) N. Kitag. is reported for the first time from India, while *Jungermannia tenerrima* Steph. and *Phaeoceros kashyapii* Asthana *et* Sriv. are new additions to the central Indian Bryoflora. However, a remarkable absence of epiphytic liverworts in the entire region surveyed has been noticed. Characteristic features with illustrations of liverworts and hornworts have been provided.

Key words: Hepatics, Anthocerotes, Tamia, Patalkot, Madhya Pradesh

INTRODUCTION

Floristic studies on Bryophytes in general, and liverworts and hornworts in particular, have received very little attention, and there is an urgent need to prepare regional floras of Bryophytes of India. However, some contributions have already been made by Pande and Srivastava (1952), Bapna (1958), Bapna and Vyas (1962), Hattori (1966, 1971), Kachroo (1969), Lal and Parihar (1979), Tewari and Pant (1994), Parihar *et al.* (1994), Bapna and Kachroo (2000). As far as floristic studies on Hepaticae of central India is concerned, Pande and Srivastava (1952), and Lal and Parihar (1979) have provided a list of Hepatics of Pachmarhi and Amarkantak respectively. Studies on Hepatics and Anthocerotes of Tamia hills and Patalkot valley have not received any attention; however, pteridophytic flora of this region was earlier provided by Vasudeva and Bir (1987), and Khare (1999).

Tamia hills (*ca* 1,000 m) and Patalkot valley (*ca* 400 m) are a part of the Satpura ranges. They are situated about 100 km south-east of Pachmarhi. The topography of Tamia exhibits deep ravines (Khuds) between the red sand stone hills made up of sedimentary rocks, composed mainly of red and yellow clay mixed with gravel. Frequent perennial streams flow in the deep ravines. The Patalkot valley is unique, giving an appearance of a piece of land that abruptly sank to a depth of 700 m; it is bordered by steep and straight hills, like a well. The valley is isolated with only 12 villages consisting of 265 families and about 1,614 individuals of the Bharia tribe. The entire region is spread over *ca* 79 sq. km.

The steep valley is endowed with dense forest cover, providing suitable conditions for the growth of Bryophytes, though only thalloid liverworts and mosses are dominant. A river, locally known as *Dudhi*, flows down the Valley near Rajakhoh, a hideout of a former king.

The region of Tamia hills and Patalkot valley is neither too hot nor too cold (temperature ranges from minimum 4 ^{0}C to 38 ^{0}C maximum) and remains pleasant throughout the year. There is not much variation in climate and altitude around Tamia region. The average annual rainfall in this region is about 200 cm. The suitable temperature, low light intensity, adequate soil moisture and presence of perennial streams, collectively provide favourable conditions for the luxuriant growth of liverworts. Some liverworts like *Dumortiera hirsuta* (Sw.) R. Bl. *et* Nees, *Pallavicinia lyellii* (Hook.) Gray and *Riccardia santapaui* Udar *et* Sriv. flourish under the dripping water on the side rocks of the deep ravines in Tamia. It is surprising to note that despite all favourable conditions, epiphytic liverworts are completely missing in these regions. This may be due to either unsuitable nature of forest vegetation (tree bark and leaves), or lack of specific conditions for epiphytic growth of liverworts.

MATERIAL AND METHODS

Plant specimens collected from Tamia and Patalkot (Dist. Chhindwara, Madhya Pradesh) have been deposited in the Bryophyte Herbarium, National Botanical Research Institute, Lucknow (LWG). Morphological and anatomical studies were done by observing on Glycerine

mounted slides. Line drawing illustrations have been prepared using Camera Lucida.

DESCRIPTIONS

I **Jungermanniales** Limpr.

A. **Jungermanniaceae** Reichenb.

a. ***Jungermannia*** L.

1. ***Jungermannia (Luridae) tenerrima*** Steph., Spec. Hepat. 6: 93, 1917. (Fig. 1, 1-5).

Plants medium to large, up to 10 mm long; light green. Stem simple, triangular in outline, 0.3 mm wide, 0.25 mm in diameter, 7-8 cells across, cortical cells slightly thick-walled. Rhizoids colourless. Leaves obliquely inserted, slightly decurrent dorsally in a single row spreading horizontally, ovate, 1 mm long and 1 mm wide, widest at base, obtuse at apex; marginal cells 36-48 x 28 µm, median cells 40-44 x 28-40 µm, basal cells 64-80 x 24-28 µm, cells thin-walled non-trigonous.

Ecology and Distribution: Plants grow on soil-covered rocks under moist conditions near Rajakhoh at Patalkot valley.

Specimen Examined: INDIA: Madhya Pradesh, Chhindwara, Patalkot valley, Rajakhoh (*ca* 400 m), 20.xii.1993. Leg. V. Nath & A.K. Asthana. 205725 (LWG). Det. V. Nath & A.K. Asthana.

B. **Lophoziaceae** Cavers

a. ***Lophozia*** (Dum.) Dum.

2. ***Lophozia mayebarae*** (Hatt.) N. Kitag., J. Hattori Bot. Lab. 29: 106, 1966. (Fig. 1, 6-12).

Basionym: *Cephalozia mayebarae* Hatt., J. Hattori Bot. Lab. 3: 37, 1948.

Plants very small, light brown, in loose tufts. Stem up to 5 mm long, 0.6 to 0.8 mm wide. Stem, 5-6 cells across in transverse section, formed of undifferentiated cells. Leaves distantly arranged, transverse to obliquely inserted, non-decurrent, quadrate to oblong-ovate 0.18-0.3 mm wide and upto 0.3 mm long, bilobed, sinus 1/6-1/3 the leaf length, lobes more or less unequal, sub-acute obtuse. Under leaves lacking, apical cells 15 x 12 µm, marginal cells 16-20 x 8-12 µm, median cells 28-32 x 12-24 µm, basal cells 40-48 x 20 µm cells thin-walled non-trigonous, hyaline or brown. Perianth not seen.

Ecology and Distribution: Plants grow over dead logs in shady habitat at Tamia.

Specimen Examined: INDIA: Madhya Pradesh, Chhindwara, Tamia (*ca* 1000 m), 10.x.1992. Leg. V. Nath & A.K. Asthana. 205497 (LWG). Det. V. Nath & A.K. Asthana.

II **Metzgeriales** Schust. em. Schljak.

A. **Aneuraceae** Klinggr.

a. ***Riccardia*** S. Gray

3. ***Riccardia santapaui*** Udar *et* Srivastava, Rev. Bryol. Lichenol. 39(1): 155-159, 1973. (Fig. 2, 1-2).

Thallus dark green, in dense and compact patches, robust usually 35-50 mm long, 1-1.75 mm wide; closely pinnately branched, branches opposite, margin entire, apices slightly broader. Rhizoids scarcely present. Main thallus axis is nearly biconvex in cross-section, 6-7 cells thick in the middle, 2-3 cells wide and ultimately unistratose at the margins, epidermal cells smaller and more or less rectangular in shape.

Ecology and Distribution: Grows luxuriantly in dense patches on rocks under dripping water at Tamia valley (near Chhota Mahadeo).

Specimens Examined: INDIA: Madhya Pradesh, Chhindwara, Tamia, on way to Chhota Mahadeo (*ca* 950 m), 10.x.1992, Leg. V. Nath & A.K. Asthana. 205498, 205509, 205510 (LWG). Det. V. Nath & A.K. Asthana; 19.xii.1993, Leg. V. Nath & A.K. Asthana. 205693, 205696, 205697, 205699, 205700 (LWG). Det. V. Nath & A.K. Asthana.

4. ***Riccardia levieri*** Schiffn., Osterr. Bot. Zeitschr. 49: 130, 1899. (Fig. 2, 3-4).

Thallus usually green, up to 30 mm long and 1.25 mm wide, irregularly or pinnately branched, branches more or less opposite, margin entire, apices broad and obtuse. Rhizoids usually present. Main axis of the thallus convex below and nearly concave or plain above in cross-section, about 6 cells thick in the middle, thallus wing multistratose, becoming thin towards margin, edges rounded or slightly acute, epidermal cells smaller than the inner cells.

Ecology and Distribution: Grows under extremely wet conditions on rocks under water stream at Tamia (on way to Chhota Mahadeo).

Specimen Examined: INDIA: Madhya Pradesh, Chhindwara, Tamia, on way to Chhota Mahadeo (*ca* 1000 m), 10.x.1992, Leg. V. Nath & A.K. Asthana. 205510 (LWG). Det. V. Nath & A.K. Asthana.

B. **Fossombroniaceae** Evans

a. ***Fossombronia*** Raddi

5. ***Fossombronia wondraczekii*** (Corda) Dum. Rec. d'observ. P. 11, 1835. (Fig. 2, 5-10).

Basionym: *Jungermannia wondraczekii* Corda in Sturm, Deutschl. Fl. Fasc. 2, Lfg. 19-20, 30, 1830.

Plants green or yellowish green. Stem 6 mm long with a tendency of dichotomous branching, slightly thickened towards apex, rhizoids hyaline to light yellow, densely distributed over ventral surface. Leaves succubous, densely arranged towards the apex, margin undulate, cells thin-walled,

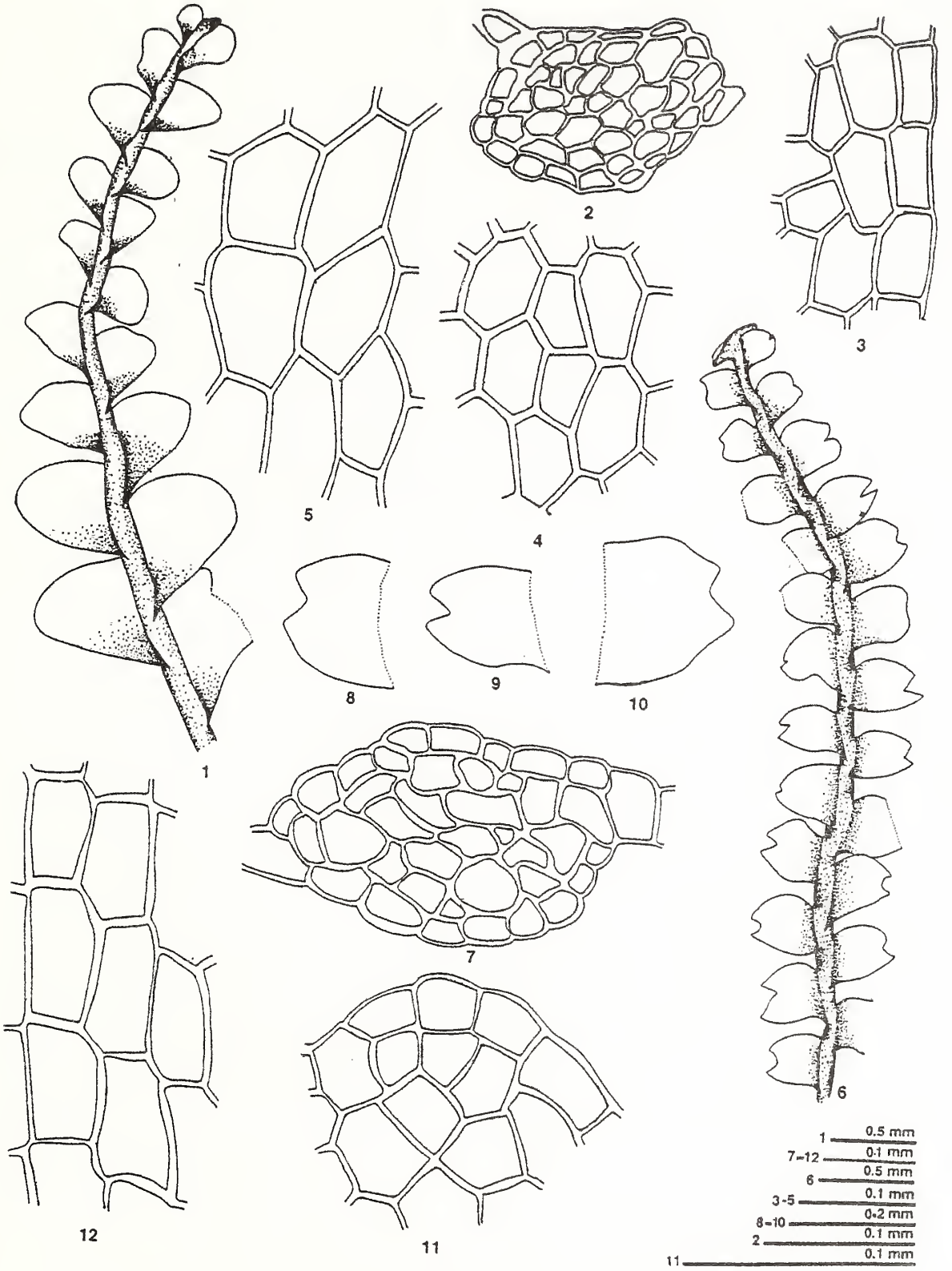

Fig. 1: 1-5: *Jungermannia tenerrima* Steph: 1. A portion of plant, 2. Cross section of stem, 3. Marginal cells of Leaf, 4. Median cells of Leaf, 5. Basal cells of Leaf; 6-12: *Lophozia mayebarae* (Hatt.) N. kitag: 6. Dorsal view of plant, 7. Cross section of stem, 8-10. Leaves, 11. Apical cells Leaf, 12. Basal cells of Leaf

marginal cells 20-24 x 34-68 µm, median cells 34-42.5 x 85 µm and basal cells 42 x 153 µm. Monoecious. Antheridia not seen. Pseudoperianth campanulate or inverted bell-shaped with wavy margin. Seta elongated. Capsule spherical, blackish-brown and exserted, dehiscence irregular, capsule wall bistratose, cells of outer layer thin-walled without any thickening, cells of inner layer in surface view with incomplete thickening bands. Spores tetrahedral to spherical, 58 µm in diameter, dark brown distal face with prominent, parallel running lamellae, which sometimes form 1 or 2 reticulations in the middle, perispore prominent and well-developed at periphery, spines bold and pointed, proximal face devoid of lamellae, but with scattered papillae, triradiate mark faintly developed. Elaters 160 µm long, 20 µm broad, 2 (3-4) spirate, yellowish brown with obtuse end.

Ecology and Distribution: Grows on soil-covered rock near Rajakhoh in Patalkot valley.

Specimen Examined: INDIA: Madhya Pradesh, Chhindwara, Patalkot, near Rajakhoh (*ca* 400 m), 6.x.1992. Leg. V. Nath & A.K. Asthana. 205474 (LWG). Det. V. Nath & A.K. Asthana.

6. ***Fossombronia kashyapii*** Srivast. *et* Udar, Nova Hedwigia 26: 816 (1975). (Fig. 2, 11-16).

Plants small, green or dull-green. Stem 7-8 mm long, dichotomously branched, apical region often tuberous, ventral surface covered with hyaline rhizoids. Leaves simple, succubous, quadrate or sub-quadrate, obliquely inserted, arranged in two lateral rows, margins undulate, marginal cells 28 (-62.4) x 24 µm, median cells 60 (-163) x 28-43 µm. Dioecious. Antheridia not seen. Pseudoperianth campanulate, margin irregularly lobed. Capsule spherical, dark brown, dehiscence irregular, capsule wall bistratose, cells of outer layer thin-walled, without any thickening, inner layer cells in surface view with complete or incomplete thickening bands. Spores 52 µm in diameter, dark brown with thick lamellae, often forming reticulations in the middle region on distal face, usually 5 reticulations across the diameter with a range of 1-8 lamellae continuous usually forked at periphery, spines and perispore well-developed, proximal face devoid of lamellae, with some short and scattered low lamellae and faintly developed triradiate mark. Elater 160-258 µm long, usually trispirate.

Ecology and Distribution: Grows on rocks under moist and exposed conditions at Tamia.

Specimen Examined: INDIA: Madhya Pradesh, Chhindwara, Tamia (*ca* 1,000 m), 10.x.1992, Leg. V. Nath & A.K. Asthana. 205487 (LWG). Det. V. Nath & A.K. Asthana.

C. ***Pallaviciniaceae*** Migula em. Schust.

a. ***Pallavacinia*** S. Gray

7. ***Pallavacinia lyellii*** (Hook.) Gray. J. Bot. Brit. Foreign 3: 302, 1865. (Fig. 3, 1-6).

Basionym: *Jungermannia lyellii* Hook., Brit. Jung. Pl. 77, 1816.

Thallus prostrate, 70 mm long, 5 mm wide, light green, dichotomously branched at apex, margin entire. Rhizoids scarcely present. Thallus usually 11 cells high in the middle and has a prominent midrib, which gradually passes on both sides into a broad lamina, midrib more or less 0.5 mm broad with central conducting strand composed of thick-walled cells, cells usually 30 in number. Cup-shaped involucre having thick fringe of hairs at mouth. Perianth and sporophyte not seen.

Ecology and Distribution: Grows on soil-covered rocks under extremely moist conditions at Tamia, on way to Chhota Mahadeo.

Specimens Examined: INDIA: Madhya Pradesh, Chhindwara, Tamia, Chhota Mahadeo (*ca* 954-1000 m), 10.x.1992. Leg. V. Nath & A.K. Asthana. 205501, 205502, 205504, 205505, 205506, 205510, 205511 (LWG); 19.xii.1993, Leg. V. Nath & A.K. Asthana. 205682, 205702, 205703, 205704 (LWG). Det. V. Nath & A.K. Asthana.

III. **Marchantiales** Limpr.

A. ***Targioniaceae*** Endl.

a. ***Targionia*** L.

8. ***Targionia hypophylla*** L. Spec. Plant. 1604, 1753. (Fig. 3, 12-16).

Plants yellowish green, thallus up to 10 mm long, 3 or rarely 4 mm broad, ventral surface purplish; scales purplish, delicate with or without appendage, pores nearly rounded. Dioecious, male plants not seen in our collection. Female thalli with dark, boat-shaped involucre around sporophyte near the apex on ventral surface. Spores dark brown-black, 60-68 µm in diameter, sporoderm minutely reticulate, forming a fine mesh all over, distal face with some larger reticulations, usually 4-5 across the diameter, proximal face with irregular folds or lamellae. Elaters usually 170-306 µm long with 2 or rarely 4 spiral thickening bands.

Ecology and Distribution: Plants grew over soil-covered rocks under exposed conditions at Patalkot valley, near Rajakhoh and at Tamia near Chhota Mahadeo.

Specimens Examined: INDIA: Madhya Pradesh, Chhindwara, Patalkot (*ca* 400 m), 6.x.1992. Leg. V. Nath & A.K. Asthana. 205472 (LWG) Det. V. Nath & A.K. Asthana; Tamia (*ca* 952 m), 11.x.1992. Leg. V. Nath & A.K. Asthana. 205526 (LWG). Det. V. Nath & A.K. Asthana.

b. ***Cyathodium*** Kunze

9. ***Cyathodium cavernarum*** Kunze in Lehm., Pugillus 6: 17,

Fig. 2: 1, 2. *Riccardia santapaui* Udar *et* Sriv.: 1. Plant, 2. Cross section of thallus; 3, 4. *Riccardia levieri* Schiff.: 3. Plant, 4. Cross section of thallus; 5-10: *Fossombronia wondraczekii* (Corda) Dum.: 5. Plant, 6. Apical marginal cells of thallus, 7. Inner lining layer of capsule, 8. Spore (distal face), 9. Spore (proximal face), 10. Elater with bispiral thickening bands. 11-16: *Fossombronia kashyapii* Sriv. *et* Udar.: 11. Plant, 12. Apical marginal cells of thallus, 13. Inner lining layer of capsule, 14. Spore (proximal face), 15. Spore (distal face), 16. Elater with trispiral thickening bands.

1834. (Fig. 3, 7-11).

Thalli yellowish green, small, delicate, 3-5 or rarely 8 mm long, 2-3 or rarely 4 mm wide, dichotomously branched at apex, repeated dichotomy results in a fan-shaped thallus, cavernous in nature, midrib not present. Monoecious. Antheridia not seen. Involucre present near the margin in the apical region of thallus, globose, non-hairy, cleaved into two lips, rim of involucre bordered with 2-3 rows of thick-walled cells. Capsule ovoid, dark brown. Spores blackish brown, 52-56 µm in diameter, sporoderm spinose-baculate. Elaters up to 561 µm long with bispiral thickening bands.

Ecology and Distribution: Plants grow on soil and soil-covered rocks in damp pockets at Tamia near Chhota Mahadeo.

Specimens Examined: INDIA: Madhya Pradesh, Chhindwara, Patalkot, near Rajakhoh (*ca* 953 m), 6.x.1992. Leg. V. Nath & A.K. Asthana 205469 (LWG); Tamia, Chhota Mahadeo, 11.x.1992. Leg. V. Nath & A.K. Asthana. 205518, 205527 (LWG). Det. V. Nath & A.K. Asthana.

B. ***Aytoniaceae*** Cavers

a. ***Asterella*** Beauv.

10. ***Asterella wallichiana*** (Lehm. *et* Lindb.) Grolle. J. Hattori Bot. Lab. 11: 8, 1954.

(Fig. 4, 1-4)

Basionym: *Fimbriaria wallichiana* in Lehm., Pugillus 4: 4, 1832.

Plants green, thallus up to 30 mm long, 3 mm broad, linear, dichotomously branched, dorsal surface nearly flat, margin wavy usually purple, apex notched; pores large, surrounded by 3 rings of 6 cells each; scales purplish, triangular with an acuminate appendage, sometimes unequally divided. Dioecious. Male plants not seen. Female receptacle terminal at apex, with 2-5 lobes, stalked, stalk 2 mm long, perianth nearly horizontal, membranous, beak-like, exserted. Spores dark brown, 63 µm in diameter, sporoderm papillose with a predominantly lamellate pattern, sometimes with a tendency to form reticulations. Elaters yellow to light brown with 1-2 spiral thickening bands, up to 150 µm long.

Ecology and Distribution: Plants grow over rocks and soil-covered rocks in exposed as well as shady places at Tamia, on way to Chota Mahadeo.

Specimens Examined: INDIA: Madhya Pradesh, Chhindwara, Tamia, Chota Mahadeo (*ca* 1,000 m), 10.x.1992. Leg. V. Nath & A.K. Asthana. 205489, 205519 (LWG); 19.xii.1993. Leg. V. Nath & A.K. Asthana. 205680, 205681 (LWG). Det. V. Nath & A.K. Asthana.

b. ***Plagiochasma*** Lehm. *et* Lindb.

11. ***Plagiochasma appendiculatum*** Lehm. *et* Lindb. Pugillus 4: 14, 1832. (Fig. 4, 12-15)

Thallus thick forming large patches, green to dark green up to 32 mm long and 6 mm wide, dichotomously divided; lobes obcordate, dorsal surface smooth with distinct pores, concave, margins undulate, slightly crenulate; ventral surface with purple tinge, scales in 1 row on each side of the midrib, purple, widely lunate in shape with a large appendage, constricted at base, obtuse, sometimes ovate with slightly acute apex, midrib gradually passing into the lamina and inconspicuous towards base. Male receptacles not seen. Female receptacles with very short stalks up to 4 lobed (in our specimens). Spores yellow, sporoderm lamellate - reticulate 68-80 µm in diameter. Elaters yellowish-brown, 340-390 µm long with bispiral thickening bands.

Ecology and Distribution: Plants grow on soil-covered rocks at Tamia, on way to Chota Mahadeo and at Patalkot.

Specimens Examined: INDIA: Madhya Pradesh, Chhindwara, Tamia, Chota Mahadeo (*ca* 950 m), 19.xii.1993. Leg. V. Nath & A.K. Asthana 205684, 205716, 205717 (LWG); Rajakhoh, Patalkot valley, Rajakhoh (*ca* 400 m), 20.xii.1993. Leg. V. Nath. & A.K. Asthana. 205731 (LWG). Det. V. Nath & A.K. Asthana.

12. ***Plagiochasma intermedium*** Lindbg. *et* Gott., Syn. Hep. 513, 1844. (Fig. 4, 5-11)

Thalli forming patches, green to dark green, 13-20 or rarely 25 mm long and 3-5 mm wide, sometimes slightly dichotomous; lobes strap-shaped with purple and thin margin, nearly entire or dentate, dorsal surface green with distinct pores. Ventral surface with purple tinge, scales purple, lunate appendaged, usually with 2 small appendages, oblong, constricted at base, entire with nearly acute apex. Midrib gradually passing into wings. Male receptacles not seen. Female receptacle with a very short stalk, dorsal in position, with 1-4 involucres. Spores brown-dark brown, lamellate, sometimes reticulate with a prominent wing, 60 µm in diameter. Elaters yellowish, uniformly thickened without spiral bands, up to 390 µm long.

Ecology and Distribution: Plants grow on soil-covered rocks at Patalkot and at Tamia in shady as well exposed conditions.

Specimens Examined: INDIA: Madhya Pradesh, Chhindwara, Patalkot valley, near Rajakhoh (*ca* 400 m), 6.x.1992. Leg. V. Nath & A.K. Asthana. 205470 (LWG); 20.xii.1993. Leg. V. Nath & A.K. Asthana. 205728 (LWG); Tamia, Chota Mahadeo (*ca* 950 m), 11.x.1992. Leg. V. Nath & A.K. Asthana. 205516, 205525 (LWG). Det. V. Nath & A.K. Asthana.

C. **Marchantiaceae** (Bisch.) Endl.

a. ***Dumortiera*** Nees.

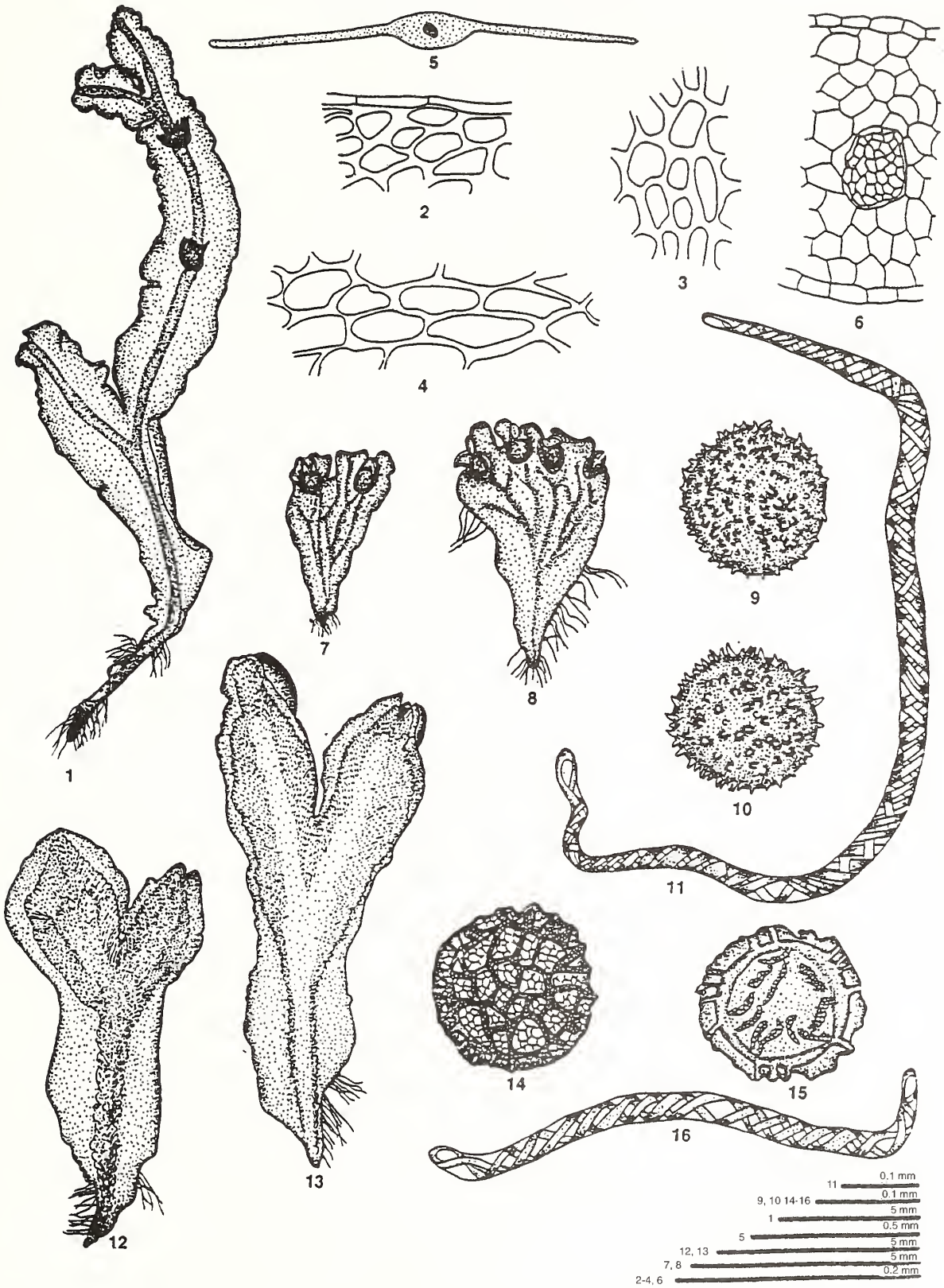

Fig. 3: 1-6: *Pallavicinia lyellii* (Hook.) Gray.: 1. Thallus with involucre, 2. Marginal cells of thallus, 3. Median cells of thallus, 4. Basal cells of thallus, 5. Cross section of thallus, 6. An enlarged portion of the same, 7-11: *Cyathodium cavernarum* Kunze: 7,8. Thalli, 9,10. Spores, 11. Elater with spiral thickening bands; 12-16: *Targionia hypophylla* L.: 12,13. Thalli with ventral involucre, 14. Spore (distal face), 15. Spore (proximal face), 16. Elater with bispiral thickening bands

13. ***Dumortiera hirsuta*** (Sw.) R. Bl. *et* Nees. Nov. Act. Leop. Carol. 7: 410, 1824. (Fig. 5, 1-4)

Basionym: *Marchantia hirsuta* Sw., Prodr. Fl. Ind. Occid. 145, 1788.

Plants dark green. Thalli in large overlapping patches. Thallus 40-50 mm (100 mm) long and 6-10 mm wide, repeatedly dichotomously branched, apex deeply cleaved, margin entire, undulate, translucent, midrib conspicuous. Dorsal surface with some papillate cells. Midrib prominent below, about 11 or more cells thick in the middle, gradually passing into the lamina formed of large cells. Dioecious, young female receptacles at apical articulation, sessile with bristles. Mature female receptacles with sporophyte not seen.

Ecology and Distribution: Plants grow luxuriantly in large patches on rocks under dripping water at Tamia, on way to Chota Mahadeo.

Specimens Examined: INDIA: Madhya Pradesh, Chhindwara, Tamia, on way to Chota Mahadeo (*ca* 1,000 m), 10.x.1992. Leg. V. Nath & A.K. Asthana. 205507, 205508, 205511, 205514, 205515 (LWG); 19.xii.1993. Leg. V. Nath & A.K. Asthana. 205701, 205714, 205715 (LWG). Det. V. Nath & A.K. Asthana.

b. ***Marchantia*** L.

14. ***Marchantia linearis*** Lehm. *et* Lindb. in Lehman, Nov. Stirp. Pug. 4: 8, 1832; Sp. Hep. 1: 187, 1900. (Fig. 5, 5-10)

Thallus thin, golden green in medium to large patches, 15-25 mm long, 2-3 mm wide, dichotomously branched, midrib narrow, black, margin entire, undulate. Pores scarce, small, up to 85 µm in diameter, bordered by 5-6 rings of cells. Thallus 14-20 cells thick in the middle, gradually or sometimes abruptly decreasing towards margins, sometimes one mucilage cavity present. Ventral surface brown, scale in 4 rows, two median rows with appendiculate scales having long decurrent base, appendages small hyaline or yellow, nearly cordate at base, apex acute with 1-2 apical cells, margin toothed usually with unicellular sharp teeth; laminal scales hyaline or purplish, orbicular, apex obtuse or rounded. Gemma cup at median region near apex, margin smooth.

Ecology and Distribution: Plants grow on moist soil under shady conditions near Chota Mahadeo at Tamia.

Specimen Examined: INDIA: Madhya Pradesh, Chhindwara, Tamia, Chota Mahadeo (*ca* 950 m), 19.xii.1993. Leg. V. Nath & A.K. Asthana. 205711, 205712, 205713 (LWG) Det. V. Nath & A.K. Asthana.

IV. **Anthocerotae** Endl.

A. **Anthocerotaceae** (Gray) Trev. em. Bharad.

a. ***Anthoceros*** (Micheli) L. em. Prosk.

15. ***Anthoceros bharadwajii*** Udar *et* Asthana, Proc. Indian Natn. Sci. Acad. B51 (4): 484, 1985. (Fig. 6, 1-4).

Thalli fan-shaped to radially oriented, dark green, margin dissected, radially oriented thalli up to 9 mm (10 mm) wide, spongy in nature with prominent mucilage chambers clearly seen along the margin of the thalli. Involucre up to 3 mm long with a narrow mouth. Epidermal layer of capsule wall with 6-11 stomata / sq. mm, each stoma up to 65 µm long and up to 50 µm wide with reniform guard cells, surrounded by 6-7 more longer than broad epidermal cells with uniformly thickened radial walls. Spores brown or dark brown, 35-44 µm (55 µm) in diameter with spinulate to rather blunt projections forming reticuloid pattern, proximal face marked with distinct triradiate mark ending shortly before the periphery, bordered with unsculptured stripe on both the sides of ray, slightly arched. Pseudoelaters light brown, thin-walled, 120 µm long, usually 4 celled, sometimes branched.

Ecology and Distribution: Plants grow luxuriantly on soil-covered rocks under fairly moist conditions at Tamia.

Specimen Examined: INDIA: Madhya Pradesh, Chhindwara, Tamia (*ca* 1000 m), 10.x.1992. Leg. V. Nath & A.K. Asthana, 205488 (LWG). Det. A.K. Asthana & V. Nath.

B. **Phaeocerotaceae** Bharad.

a. ***Phaeoceros*** Prosk.

16. ***Phaeoceros laevis*** (Linn.) Prosk. subsp. ***laevis*** Prosk. Rapp. et Comm. 8. Congr. Intern. Bot. Paris 14-16: 69, 1954 (Fig. 6, 5-8)

Basionym: *Anthoceros laevis* Linn. Spec. Plant. 2: 1139, 1753.

Plants dioecious. Female thalli fan-shaped, light or dark green, branched, up to 11 mm long, 8-10 mm wide at apex, deeply lobed, margin entire-wavy, compact. Involucre cup-shaped cylindrical, 2 mm (-5 mm) long with wide mouth, compact, smooth, epidermal layer of capsule wall stomatiferous with 6-7 stomata/ sq. mm, each stoma 50-75 µm long and 40 µm wide with two reniform guard cells, surrounded by 5-6 more longer than broad narrow rectangular cells having uniformly thickened radial and end walls. Spores yellowish green, spherical or subspherical, 45 µm in diameter, sporoderm minutely papillate with a prominent equatorial crossitudo, proximal face with a distinct thin triradiate mark bordered by minute papillae along the rays, triradiate rays reaching to equatorial crossitudo. Pseudoelaters light brown to brown, 4 celled, 168 µm long, thin-walled.

Ecology and Distribution: Plants grow on rocks near streams at Chota Mahadeo, Tamia.

Specimen Examined: INDIA: Madhya Pradesh, Chhindwara, Tamia, Chota Mahadeo (*ca* 950 m), 19.xii.1993. Leg. V. Nath & A.K. Asthana. 205687 (LWG). Det. A.K. Asthana & V. Nath.

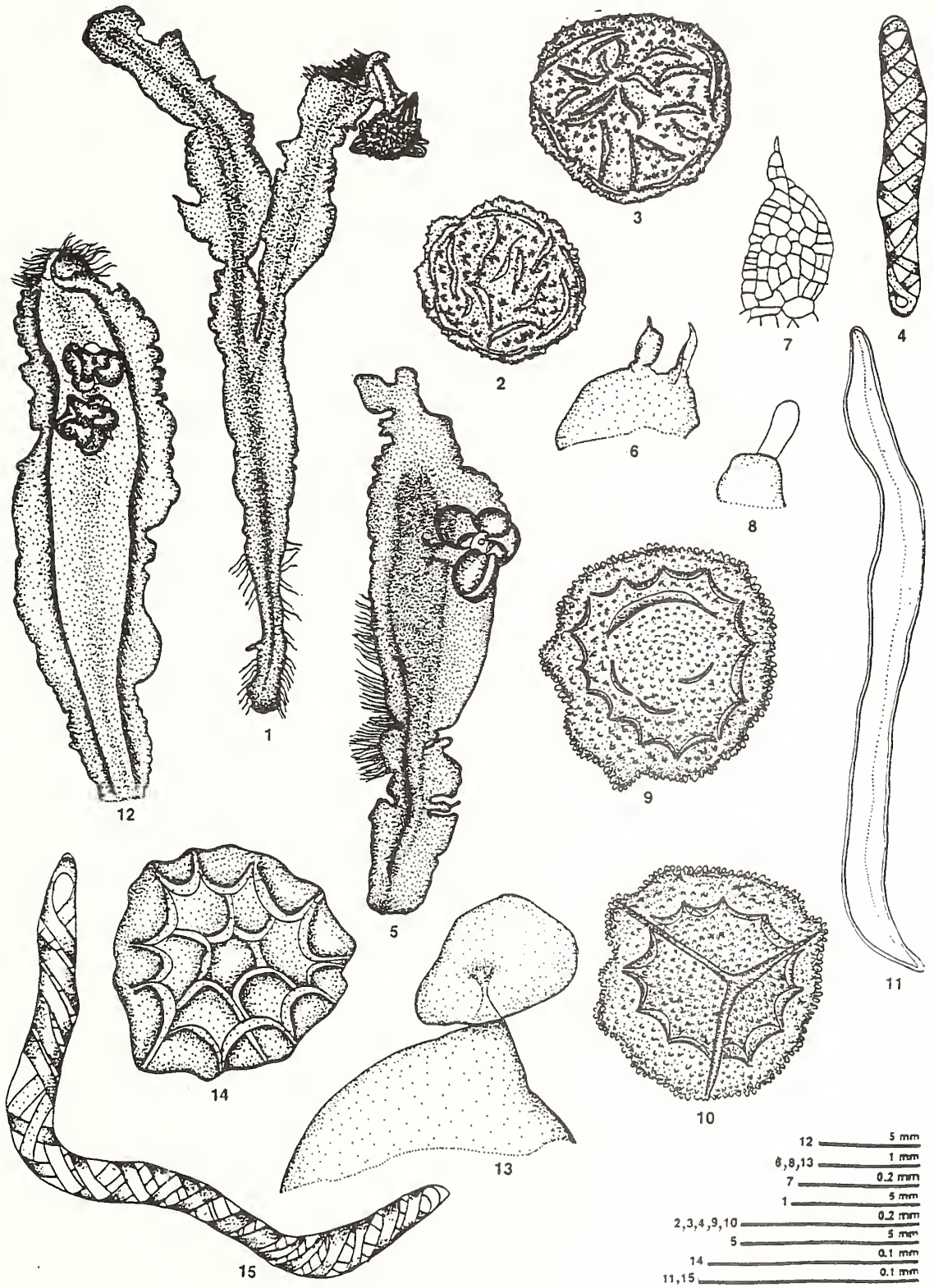

Fig. 4: 1-4: *Asterella wallichiana* (Lehm. *et* Lindb.) Grolle, 1. Thallus with female receptacle, 2,3. Spores, 4. Elater with bispiral thickening bands; 5-11. *Plagiochasma intermedium* Ldbg. *et* Gott. 5. Thallus with female receptacle, 6. Ventral scale, 7,8. An enlarged view of the same, 9. Spore (distal face), 10. Spore (proximal face), 11. Elater without thickening bands; 12-15: *Plagiochasma appendiculatum* L. *et* L. 12. Thallus with female receptacle, 13. Ventral scale, 14. Spore, 15. Elater with bispiral thickening bands

17. ***Phaeoceros laevis*** (Linn.) Prosk. subsp. ***carolinianus*** (Michx.) Prosk., Rapp. *et* Comm. 8. *Congr. Intern. Bot.*, Paris 14-16: 69, 1954. (Fig. 6, 9-11)

Basionym: *Anthoceros carolinianus* Michx., Fl. Bor. America 2: 280, 1803.

Plants monoceious. Thalli fan-shaped light or dark green, deeply lobed, usually 12 mm long and 10 mm wide with fanning apex and narrowing base, compact. Androecial chambers scattered irregular over the dorsal surface. Involucre cylindrical, 2-4 mm long, smooth, compact, narrow at mouth. Epidermal layer of capsule wall stomatiferous with 3-10 stomata/ sq. mm, up to 80 µm long and 40 µm wide, with two reniform guard cells surrounded by usually 6 more longer than broad epidermal cells, cells with thickened radial and end walls. Spores yellowish green, 35 µm in diameter, sporoderm minutely papillate with a prominent equatorial crossitudo, proximal face with a distinct triradiate mark, triradiate rays thin and bordered with minute papillae all along its length, reaching up to equatorial crossitudo. Pseudoelaters yellowish brown, thin-walled, up to 150 µm long with irregular thickening bands.

Ecology and Distribution: Plants grow over soil-covered rocks under moist conditions near Chota Mahadeo.

Specimen Examined: INDIA: Madhya Pradesh, Chhindwara, Tamia, Chota Mahadeo (*ca* 950 m), 19.xii.1993. Leg. V. Nath & A.K. Asthana 205708 (LWG). Det. A.K. Asthana & V. Nath.

18. ***Phaeoceros kashyapii*** Asthana *et* Sriv. Bryophyt. Biblioth. Band 42: 129, 1991. (Fig. 6, 12-18)

Plants monoecious. Thalli light green, lobed up to 6 mm long and 2-4 mm wide, fanning above and narrow at base, compact. Involucre cylindrical, smooth, up to 3 mm long, compact. Epidermal layer of capsule wall stomatiferous, each stoma with 2 reniform guard cells, surrounded by 5-6 more longer than broad epidermal cells having thickened radial and end walls. Spores yellowish green, 37.5-40 µm in diameter, sporoderm with lamellate projections and a prominent equatorial crossitudo, proximal face with a prominent and thin triradiate mark reaching to the inner border of equatorial crossitudo. Pseudoelaters pale to light brown, thin-walled, smooth, 72-100 µm long.

Ecology and Distribution: Plants were collected from soil-covered rocks under moist conditions on way to Rajakhoh at Patalkot valley.

Specimen Examined: INDIA: Madhya Pradesh, Chhindwara, Patalkot, on way to Rajakhoh (*ca* 400 m), 6.x.1992. Leg. V. Nath and A.K. Asthana. 205475 (LWG). Det. A.K. Asthana & V. Nath.

DISCUSSION

The investigation on the altitudinal distribution of liverwort and hornwort taxa growing at Tamia and Patalkot revealed that *Riccardia levieri*, *Fossombronia kashyapii*, *Lophozia mayebarae*, *Dumortiera hirsuta* and *Anthoceros bharadwajii* occur at higher altitude (*ca* 1,000 m), while *Riccardia santapaui*, *Cyathodium cavernarum*, *Marchantia linearis*, *Phaeoceros laevis* subsp. *laevis* and subsp. *carolinianus* occur at *ca* 950 m. *Pallavicinia lyellii* grows between 954-1,000 m. Apart from this, the low altitude loving taxa like *Jungermannia* (Luridae) *tenerrima*, *Fossombronia wondraczekii*, *Targionia hypophylla* and *Phaeoceros kashyapii* grow at *ca* 400 m. The most adaptive taxa are *Plagiochasma appendiculatum and P. intermedium*, which grow at a range of 400-950 m.

Lophozia mayebarae (Hatt.) N. Kitag. was earlier described from Japan by Kitagawa (1966) and was considered endemic; the present study, however, revealed the occurrence of this taxon at Tamia (Chhindwara district), which is a new record for India, hence extending the range of distribution of this species from Japan to India. Indian specimens of the above taxon closely resemble Japanese plants in plant size, stem anatomy, leaf size and non-trigonous cells; but some variations, in apical leaf cells (30-40 µm), middle and basal cells (28-33 x 40-60 µm) have been observed, which may be due to different climatic conditions of the two geographically different locations.

Phaeoceros kashyapii Asthana *et* Sriv. was first described (Asthana and Srivastava 1991) from Deoban (Western Himalaya) at *ca* 3,300 m, but recent investigation showed the occurrence of this taxon at remarkably low altitude – *ca* 400 m – at Patalkot valley (Chhindwara district), which is a new addition to the central Indian bryoflora, and it shows the adaptability of this species to grow widely in various bryogeographical regions of India. A morphological variation in the specimens of Patalkot, as compared to the plants of Deoban, is that the thallus is smaller in size, in addition to variation in diameter of spore and elater's length. *Jungermannia* (Luridae) *tenerrima* is also a new addition to the central Indian bryoflora, as earlier it was known from western and eastern Himalaya only.

The present study revealed that *Targionia hypophylla*, *Cyathodium cavernarum*, *Plagiochasma intermedium* and *Plagiochasma appendiculatum* are common at both Tamia and Patalkot valley. This growth pattern exhibits the adaptability of these taxa to grow at lower, as well as at higher altitudes and in shady or exposed conditions as compared to other taxa. *Riccardia santapaui* (Aneuraceae), *Pallavicinia*

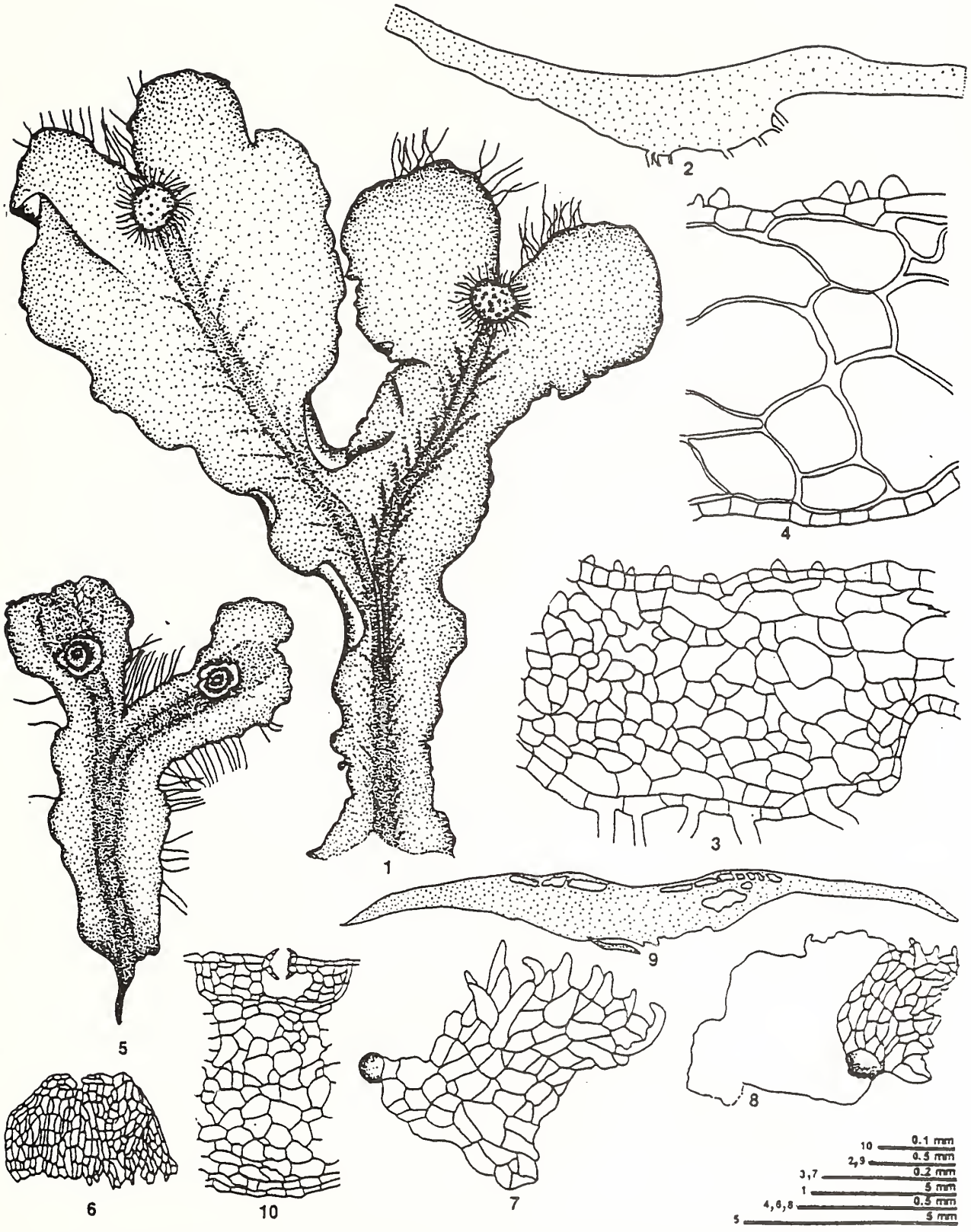

Fig. 5:. 1-4: *Dumortiera hirsuta* (Sw.) R. Bl. *et* Nees: 1. Thallus with young female discs, 2. Cross section of thallus, 3, 4. An enlarged view of the same showing papillate cells; 5-10: *Marchantia linearis* Lehm. *et* Lindb.: 5. Thallus with gemma cups, 6. Laminal scale, 7. Appendage of the scale, 8. An appendaged scale, 9. Cross section of thallus, 10. An enlarged portion of the same

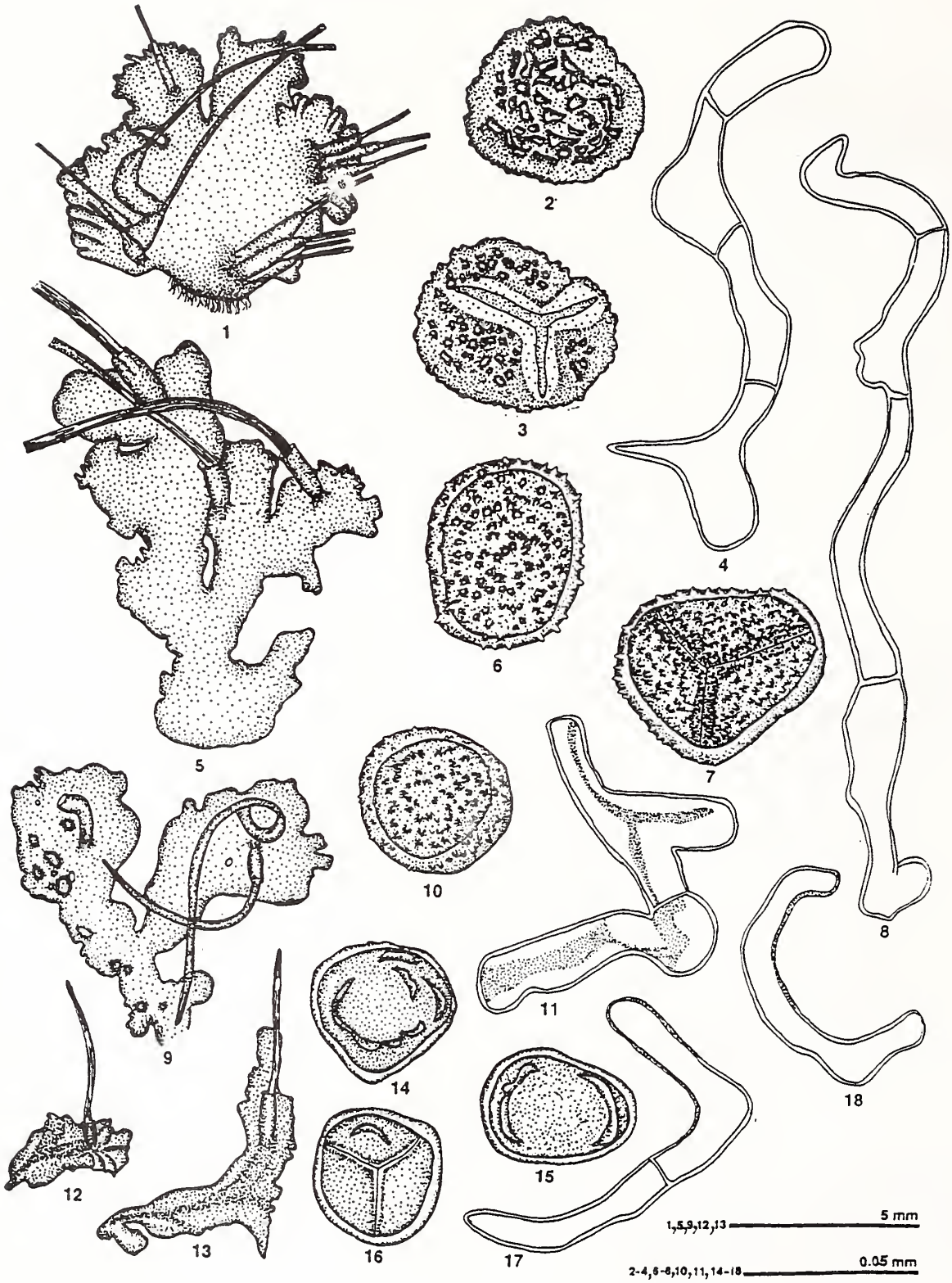

Fig. 6: 1-4: *Anthoceros bharadwajii* Udar *et* Asthana: 1. Thallus, 2. Spore (distal face), 3. Spore (proximal face), 4. Pseudoelater. 5-8: *Phaeoceros laevis* s. sp. *laevis* Prosk.: 5. Thallus, 6. Spore (distal face), 7. Spore (proximal face), 8. Pseudoelater. 9-11: *Phaeoceros laevis* s.sp. *carolinianus* (Michx.) Prosk.: 9. Monoecious thallus, 10. Spore, 11. Pseudoelater. 12-18: *Phaeoceros kashyapii*Asthana *et* Sriv.: 12, 13. Thalli, 14, 15. Spores (distal face), 16. Spore (proximal face), 17,18. Pseudoelaters

lyellii (Pallaviciniaceae) and *Dumortiera hirsuta* (Marchantiaceae) respectively form the dominant liverwort vegetation at Tamia, while *Plagiochasma intermedium* and *Plagiochasma appendiculatum* exhibit dominance in the Patalkot valley.

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SIZE COMPOSITION AND MORPHOMETRY OF INCIDENTALLY CAPTURED SEA TURTLES AT VIZHINJAM, SOUTH-WEST COAST OF INDIA[1]

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The paper deals with the size composition of incidentally captured sea turtles in different fishing gears, such as gill net, hooks and line, boat seine, and other gears at Vizhinjam coastal area from September 1998 to December 2001. The size composition and the relationships between various morphometric characters of the incidentally caught sea turtles have been discussed. Size composition of 1,216 Olive Ridleys *Lepidochelys olivacea*, 56 Green Turtles *Chelonia mydas*, 43 Hawksbills *Eretmochelys imbricata* and 5 Leatherback Turtles *Dermochelys coriacea* were studied. In the carapace length, significant variations were found among the species ($F=407.47$; $p<0.001$), year ($F=7.17$; $p<0.001$), gear types ($F=10.40$; $p<0.001$) and sex ($F=272.43$; $p<0.001$). In the weight, significant variations were noticed among the species ($F=1,325.18$; $p<0.001$), and sex ($F=345.17$; $p<0.001$). Among the incidentally caught sea turtles, significant differences were observed between the species, and sex in relationship between different morphometric characters and weight.

Key words: morphometric measurements, sea turtles, size composition, fishing gears, analysis of variation, regression equation

INTRODUCTION

The size frequency of a population is important and is an essential parameter of that population's demographic structure (Bolten 1999). By analyzing the size composition of sea turtles, habitat quality and physiological status can be understood (Bolten 1999). Morphometric data on the incidentally caught sea turtles can be used as a tool to estimate from the measurement of one body part, the weight and measurement of other parts. Morphometric characteristics of a population can help to identify the population status and to find out the species and size group that get entangled in the fishing gears. They also help to suggest measures to reduce the mortality by altering the mesh size or by any other effective conservation measures. Available information on sea turtle morphometry is restricted to nesting Olive Ridleys (Silas *et al.* 1983; James *et al.* 1989; Dash and Kar 1990) and some reports on the Green Turtle, Hawksbill, and Leatherback Turtle stranded along the Indian coast (Siraimeetan 1985; Tripathy and Choudhury 2002; Bhupathy and Karunakaran 2003). However, considerable amount of work is available on the morphometric measurements of sea turtles from Sri Lanka (Deraniyagala 1953), North Carolina (Fahy 1954), Queensland and Papua New Guinea (Limpus 1985) and from Oceanic in Azores and Baleares Islands. The literature available on the morphometry is very fragmentary in India and there is no detailed work on the morphometry of incidentally caught sea turtles. Therefore, the present study was undertaken to analyze the size composition of the stranded turtles from different fishing gears and to find out the relationship between various morphometric characteristics of incidentally caught sea turtles.

MATERIAL AND METHODS

Measurements were taken from the incidentally caught Olive Ridleys *Lepidochelys olivacea*, Green Turtles *Chelonia mydas*, Hawksbills *Eretmochelys imbricata*, and Leatherback Turtles *Dermochelys coriacea* at Vizhinjam of Kerala coast. Data were collected from September 1998 to December 2001. On locating the stranded sea turtles, different morphological measurements, such as curved carapace length and width, plastron length and width were taken for all turtles. Bolten (1999) was followed for taking measurements of different parts of the body.

RESULTS

Size composition of sea turtles

The morphometric measurements and weight of sea turtles incidentally caught in Vizhinjam, Kerala are given in Table 1.

Morphometric Relationship between different species of sea turtles

Multiway Analysis of Variance was applied to investigate the difference in the morphometric measurements among the four species of sea turtles. In the carapace length significant variations were found among the species

(F=407.47; p<0.001), year (F=7.17; p<0.001), gear types (F=10.40; p<0.001) and sex (F=272.43; p<0.001). Likewise in carapace width, significant variations were found in species (F=180.82; p<0.001), gear types (F=10.33; p<0.001) and sex (F=276.07; p<0.001), in plastron length variations were noticed among the species (F=336.00; p<0.001), year (F=6.80; p<0.001) and sex (F=224.26; p<0.001) and plastron width showed significant difference among the species (F=122.85; p<0.001), sex (F=253.59; p<0.001). In the weight significant variations were noticed among the species (F=1,325.18; p<0.001), sex (F=345.17; p<0.001) (Table 2).

Relationship between the Morphometric Characters and Weight

The relationship between morphometric characteristics and weight of different species of turtles, incidentally caught in various types of fishing gears, was tested using regression equations. The fitted line was plotted on a scatter diagram for different parameters.

The regression equations developed were i) Carapace length vs. carapace width ii) Plastron length vs. plastron width iii) Carapace length vs. weight iv) Carapace width vs. weight v) Plastron length vs. weight and vi) Plastron width vs. weight. The fitted linear and nonlinear regression equations for different morphological characters are given in Tables 3, 4, 5 and 6.

Olive Ridleys *Lepidochelys olivacea*

The carapace length vs. carapace width and plastron length vs. plastron width of the Olive Ridleys *Lepidochelys olivacea* at the Vizhinjam coastal area, Kerala showed linear relationship, while carapace length vs. weight, carapace width vs. weight, plastron length vs. weight, and plastron width vs. weight showed quadratic relationship. All the regression equations were highly significant (p<0.001) and explained more than 61% of the total variation (Table 3 and Fig. 1).

Green Turtles *Chelonia mydas*

Out of the six regression equations developed on the morphometric characteristics of the Green Turtles *Chelonia mydas* in Vizhinjam, Kerala the first three regression equations (i-iii) showed linear relationships, whereas the remaining three (iv-vi) had a quadratic relationship. All the regression equations were highly significant (p<0.001) and explained more than 80% of the total variations (Table 4 and Fig. 2).

Hawksbills *Eretmochelys imbricata*

The morphometric characteristics of the Hawksbills *Eretmochelys imbricata* in Vizhinjam, Kerala in the first three regression equations (i-iii) had a linear relationship, and the remaining (iv-vi) had the high order term with quadratic relationship. All the regression equations were highly significant (p<0.001) (Table 5 and Fig. 3).

Leatherback Turtles *Dermochelys coriacea*

The morphometric characteristics of the Leatherback Turtles *Dermochelys coriacea* in Vizhinjam, Kerala had linear relationship in all the regression equations. The regression equations were significant (p<0.001) for all the body characteristic features, except plastron length vs. plastron width and plastron length vs. weight and plastron width vs. weight (Table 6 and Fig. 4).

DISCUSSION

Silas *et al.* (1983) reported that the size of the stranded Olive Ridleys along the Orissa coast during 1983 ranged from

Table 1: Morphometric measurements and weight of different species of sea turtles incidentally caught in Vizhinjam, Kerala

Sea turtles	Carapace length (cm)	Carapace width (cm)	Plastron length (cm)	Plastron width (cm)	Weight (kg)
Lepidochelys olivacea	60.7± 7.6 (32.0-72.0) (n=1,216)	57.2 ± 7.2 (26.0-72.0) (n=1,216)	50.1 ± 5.6 (24.0-66.0) (n=1,216)	47.0 ± 5.4 (14.0-65.0) (n=1,216)	41.2 ± 6.0 (13.0-50.0) (n=1,216)
Chelonia mydas	71.6 ± 15.3 (43.5-96.0) (n=56)	60.9 ± 12.6 (41.0-86.0) (n=56)	56.4 ± 12.1 (36.0-82.0) (n=56)	51.1 ± 11.1 (32.0-76.5) (n=56)	53.7 ± 18.8 (15.0-89.0) (n=56)
Eretmochelys imbricata	48.9 ± 11.0 (25.0-68.5) (n=43)	41.4 ± 9.4 (23.0-58.0) (n=43)	36.6 ± 8.9 (21.0-54.0) (n=43)	32.6 ± 7.6 (20.0-47.0) (n=43)	22.5 ± 10.9 (4.1-45.0) (n=43)
Dermochelys coriacea	142.0 ± 19.0 (93.0-155.0) (n=5)	101.6 ± 16.3 (68.0-117.0) (n=5)	124.7 ± 19.9 (107.0-142.0) (n=5)	76.6 ± 4.3 (72.5-82.0) (n=5)	216.0 ± 60.76 (110.0-260.0) (n=5)

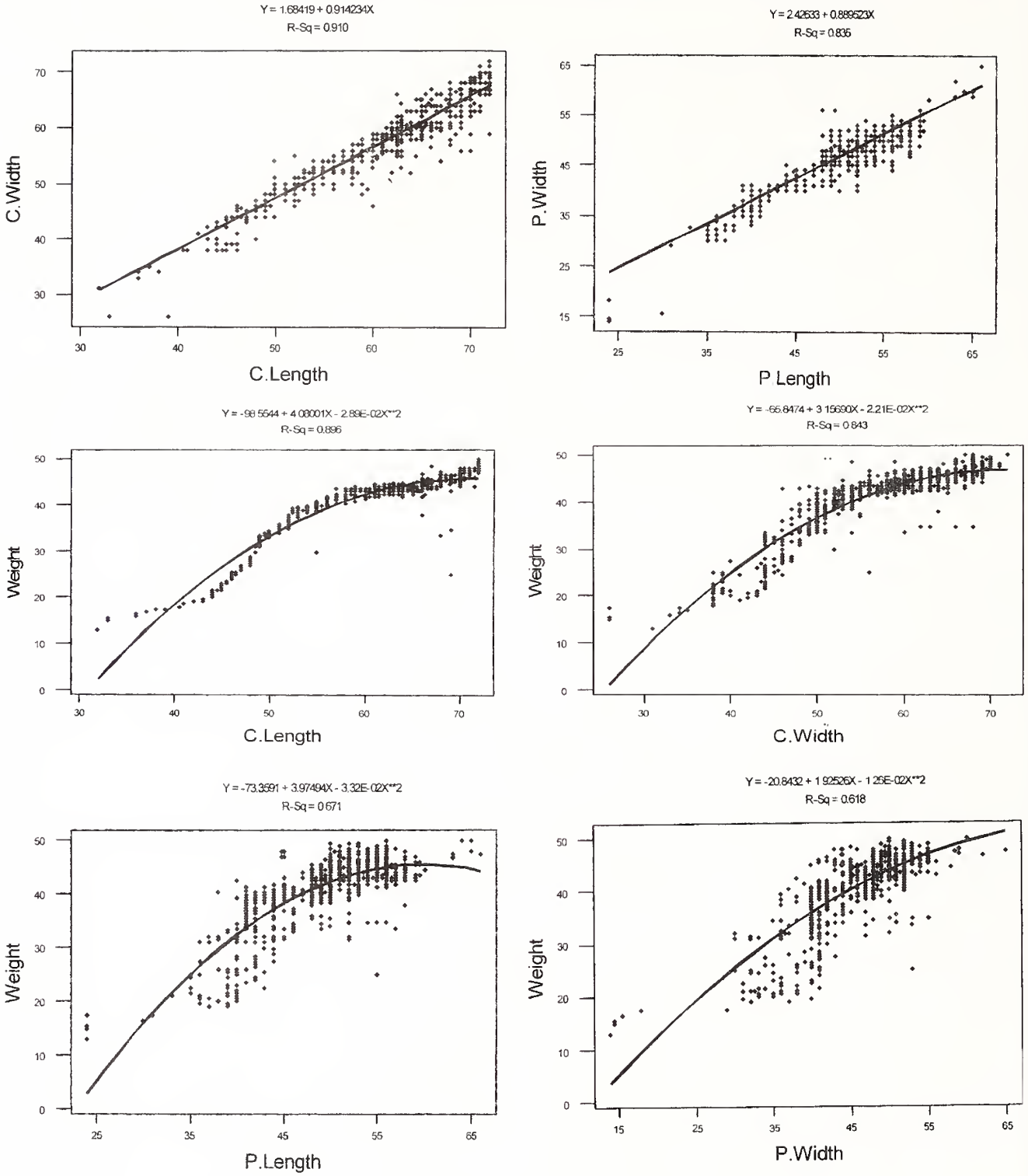

Fig. 1: Regression plots for *Lepidochelys olivacea*

51 to 72 cm in curved carapace length (mean of 62.2 cm), curved carapace width from 48 to 63 cm (mean 57.8 cm), plastron length from 44 to 57 cm (mean 51.8 cm) and plastron width from 43 to 53 cm (mean 49.3 cm). The report by Bhupathy and Karunakaran (2003) states that the size of the Olive Ridley recorded from the Nagapattinam coast of Tamil Nadu ranged from 50 to 77 cm in curved carapace length (mean 68.7±2.5 cm). Dash and Kar (1990) stated that at Gahirmatha, the range of carapace length for male olive ridleys was 67.5 to 70.0 cm and for females, it was 66.0 to

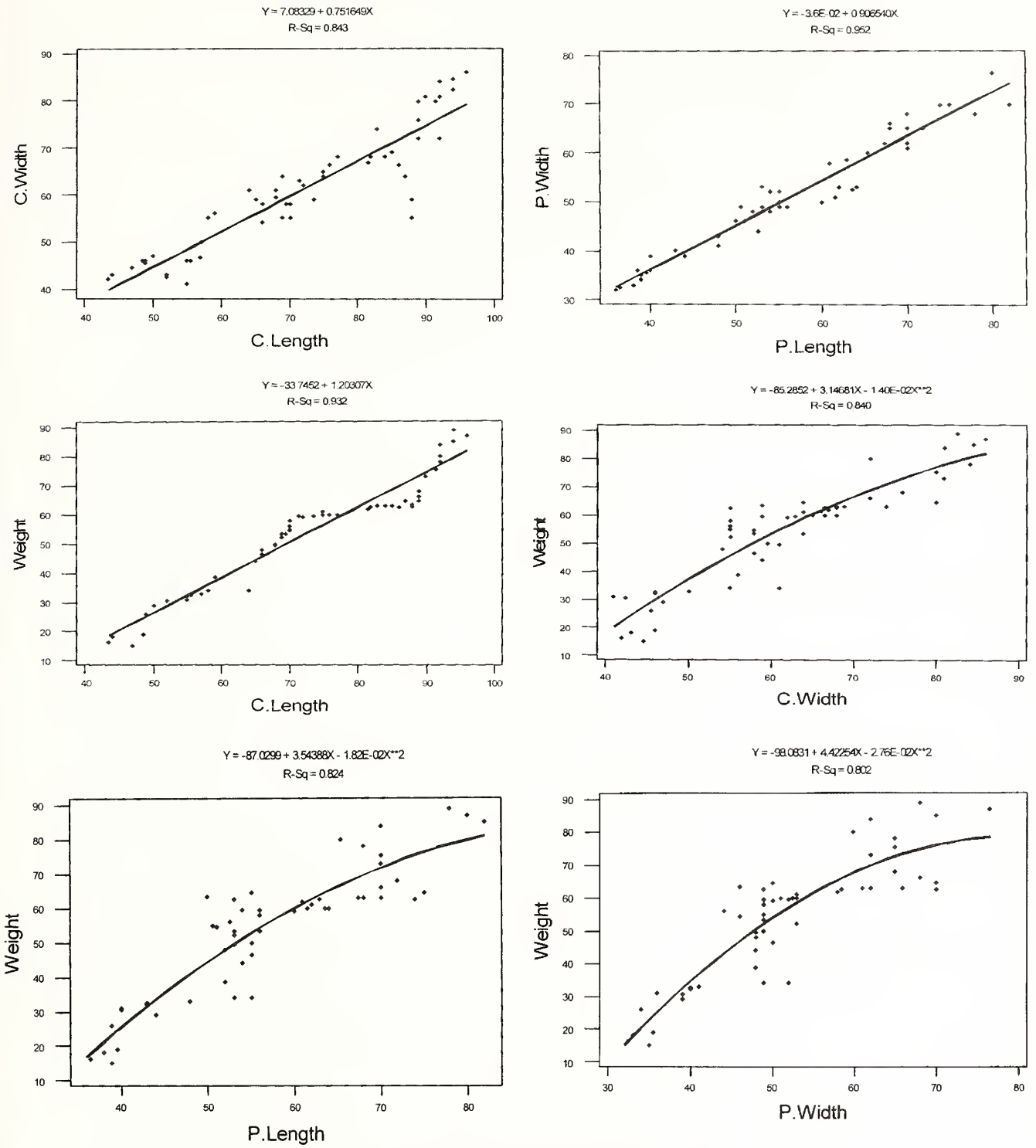

Fig. 2: Regression plots for *Chelonia mydas*

76.5 cm. In the present study, the Olive Ridley curved carapace length ranged from 32 to 72 cm with a mean of 60.7±7.6, which is slightly lower than that recorded by Silas *et al.* (1983), but differs much from that recorded by Bhupathy and Karunakaran (2003); Dash and Kar (1990). Hasbún and Vásquez (1999) quoted that the nesting Olive Ridleys in Santiago beach had a mean carapace length of 68.9 cm (range 60-85 cm, sd = 4.52). When compared to those reported sporadically from other geographical regions, the average lengths of carapace and their range of sizes clearly show that the Ridleys of the present study are smaller in size than the Ridleys of other regions, such as the north-eastern Gulf of

California (Caldwell 1962) and Honiara (McKeown 1977). Pritchard (1969) opined that the average size of Olive Ridleys was slightly larger in the Indian Ocean than elsewhere; hence it appears that there is some geographical difference in the size of the Ridleys. This is also evident from the maximum sizes recorded at Sri Lanka: 79.0 cm by Deraniyagala (1939). However, compared to earlier records, in this study both sexes showed lower carapace ranges. The Ridley is the smallest of all the sea turtles; seldom has it weighed more than 50 kg and very rarely more than 60 kg (Dash and Kar 1990). The present study showed that the average body weight of males and females were 42.7 ±3.3 kg (range: 30 to 49.5 kg) and 42.9 ±3.1 kg (range: 33 to 50 kg) respectively. Pritchard (1969) reported the average weight of 14 turtles as 78.28 ±7.58 kg, with a range of 68-97 kg. Kar and Bhaskar (1982) found the average weight of 291 turtles to be 43.4 kg. According to Zwinberg (1976), a female from Surinam had a carapace length of 69.0 cm and weighed 44 kg. McKeown (1977)

Table 2: Analysis of Variance to investigate the effect of species, year, gear types and sex on the morphometric measurements of incidentally caught sea turtles

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Analysis of Variance for Carapace Length						
Species	3	71,527.7	58,919.3	19,639.8	407.47	0.001
Year	3	783.5	1,036.8	345.6	7.17	0.001
Gear types	3	55.1	1,504.1	501.4	10.40	0.001
Sex	2	26,261.6	26,261.6	13,130.8	272.43	0.001
Error	1,309	63,092.7	63,092.7	48.2		
Total	1,323	1,61,924.6				
Analysis of Variance for Carapace Width						
Species	3	29,179.3	22,620.4	7,540.1	180.82	0.001
Year	3	519.1	588.7	196.2	4.71	0.003
Gear types	3	24.1	1,292.6	430.9	10.33	0.001
Sex	2	23,024.3	23,024.3	11,512.1	276.07	0.001
Error	1,309	54,584.5	54,584.5	41.7		
Total	1,323	7,509.3				
Analysis of Variance for Plastron Length						
Species	3	32,300.6	28,659.8	9,553.3	336.00	0.001
Year	3	203.9	580.4	193.5	6.80	0.001
Gear types	3	356.7	352.5	117.5	4.13	0.006
Sex	2	12,752.4	12,752.4	6,376.2	224.26	0.001
Error	1,231	35,000.7	35,000.7	28.4		
Total	1,245	80,727.3				
Analysis of Variance for Plastron Width						
Species	3	13,291.8	9,106.1	3,035.4	122.85	0.001
Year	3	186.0	236.1	78.7	3.18	0.023 ns
Gear types	3	177.7	160.7	53.6	2.17	0.090 ns
Sex	2	12,531.4	12,531.4	6,265.7	253.59	0.001
Error	1,232	30,440.8	30,440.8	24.7		
Total	1,246	56,735.8				
Analysis of Variance for Weight						
Species	3	1,75,574	1,63,749	54,583	1,325.18	0.001
Year	3	201	639	213	5.17	0.002 ns
Gear types	3	97	277	92	2.24	0.082 ns
Sex	2	28,435	28,435	14,217	345.17	0.001
Error	1,265	52,104	52,104	41		
Total	1,279	2,56,726				

ns = Statistically not significant, Seq SS = Sequential sum of square, Adj SS = Adjusted sum of square, Adj MS = Adjusted mean square, F = Ratio, P = Probability, DF = Degree of freedom

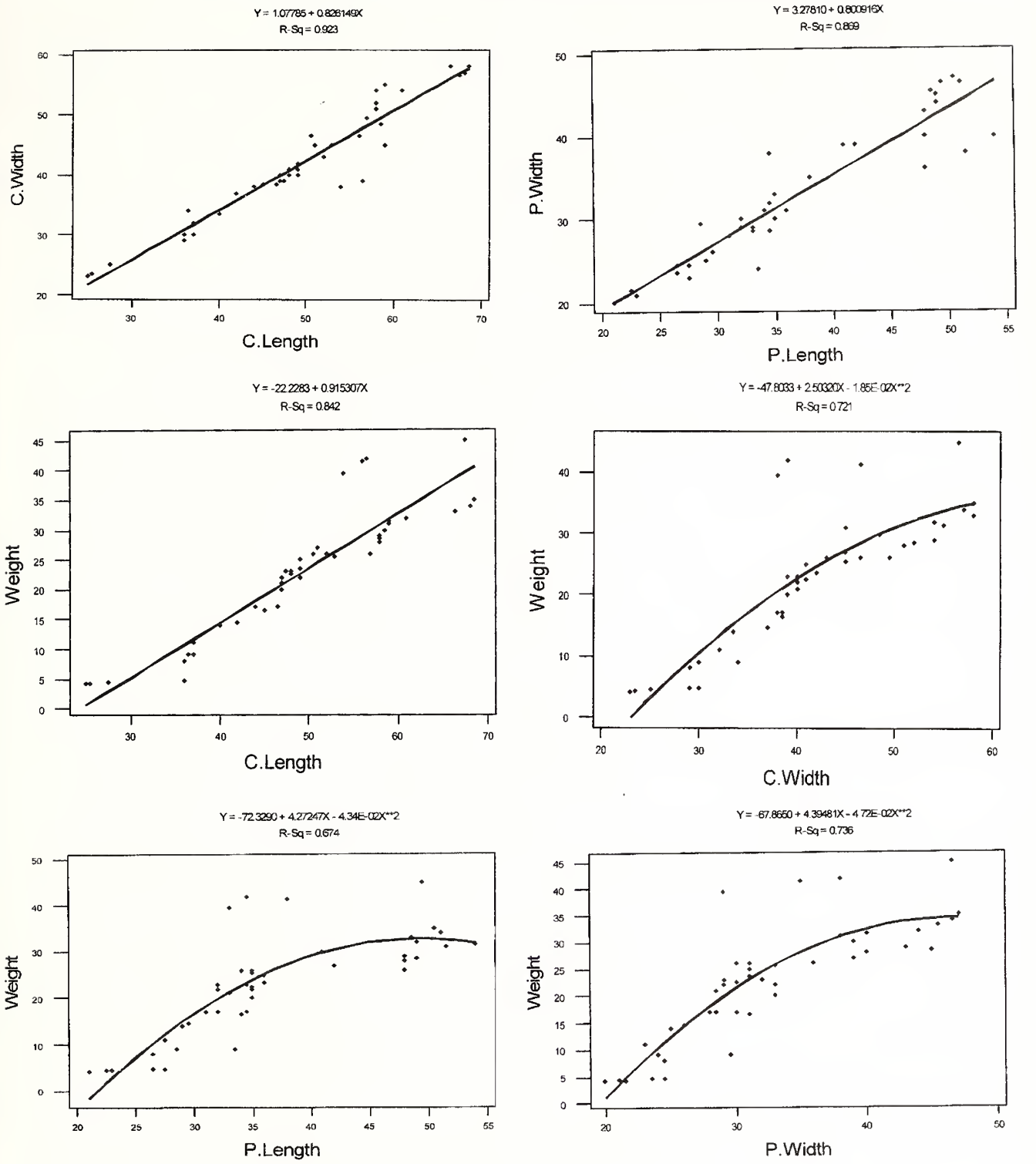

Fig. 3: Regression plots for *Eretmochelys imbricata*

mentioned a copulating male and female near Honiara with a carapace length of 65 and 47.0 cm and weight 40 kg and 44.5 kg respectively. The weight of Olive Ridleys of the present study is in consistence with earlier studies.

Little information is available, so far, in the literature relating to the body size and weight of subadults of Olive Ridley. Only few occasional stray individuals were captured in fishing gears or were found dead on the coast of Islands or mainland beaches. The only substantial sample of subadults of Olive Ridleys from outside the Indian Ocean appears to have been recorded near Japan (Nishimura *et al.* 1972) and the carapace length ranged from 21.0-62.0 cm. Nishimura

et al. (1972) opined that the Pacific Ridley has a trend towards the demersal life and the individuals that drifted to the Japanese waters were subadults. Deraniyagala (1953) mentioned that the dimensions of subadult female from Mortuva, Sri Lanka, had carapace length of 49.0 cm, carapace width of 45.0 cm and plastron length of 40.0 cm. Hughes and Richard (1974) suggested that in South Africa most turtles caught in shark nets were subadults. Hillestad *et al.* (1982) stated that the turtles captured by trawlers in Georgia and South Carolina from 1978 to 1979, were subadults. In the present study, the size of the subadults ranged from 32.0-56.0 cm (mean = 50.2 ±8.3 cm) and the weight from 13-39 kg (mean = 28.4 ± 8.2 kg) and they formed a substantial portion of the incidental catches.

Martin *et al.* (2002) recorded that the average carapace length of the Green Turtle was 93.3 cm in Cuba. In India, Siraimeetan (1985) pointed out that the curved carapace length of Green Turtle males ranged from 33-81.5 cm and the most dominant size group was 65-75 cm; the female ranged between 41-80.5 cm and the majority of the turtles belonged to the size group 65-75 cm. The weight of the males ranged from 3.5-55 kg and the females from 6.5 to 51.5 kg. The modal weight of

Table 3: Regression equation models among the morphometric measurements and weight of the *Lepidochelys olivacea*

Variable	N	Regression equation	R^2 (%)	Model F	P
Carapace Length vs carapace width	1,216	Carapace width^2 = 1.68 + 0.91 Carapace length	91.0	12,319.6	<0.001
Plastron length vs plastron width	1,143	Plastron width = 2.43 + 0.89 Plastron length^2	83.5	5,780.18	<0.001
Carapace length vs weight	1,179	Weight = -98.50 + 4.08 Carapace length - 0.0289 Carapace length^2	89.6	5,046.01	<0.001
Carapace width vs weight	1,179	Weight = -65.84 + 3.15 Carapace width - 0.022 Carapace width^2	84.3	3,158.81	<0.001
Plastron length vs weight	1,134	Weight = -73.3 + 3.97494 Plastron length - 0.033 Plastron length	67.1	1,159.51	<0.001
Plastron width vs weight	1,139	Weight = -20.84 + 1.93 Plastron width - 0.0126 Plastron width^2	61.8	919.528	<0.001

Table 4: Regression equation models among the morphometric measurements and weight *of Chelonia mydas*

Variables	N	Regression equation	R^2 (%)	Model F	P
Carapace length vs carapace width	56	Carapace width = 7.08 + 0.752 Carapace length	84.3	289.90	<0.001
Plastron length vs plastron width	56	Plastron width = -3.6 + 0.907 Plastron length	95.2	1,071.38	<0.001
Carapace length vs weight	53	Weight = -33.7 + 1.20 Carapace length	93.2	702.91	<0.001
Carapace width vs weight	53	Weight = -85.28 + 3.14 Carapace width 0.014 Carapace width^2	84	131.598	<0.001
Plastron length vs weight	53	Weight = - 87.02 + 3.54 Plastron length - 0.018 Plastron^2 - 98.08	82.4	117.149	<0.001
Plastron width vs weight	53	Weight = -1.0 + 4.42 Plastron width - 0.03 Plastron width^2	80.2	101.528	<0.001

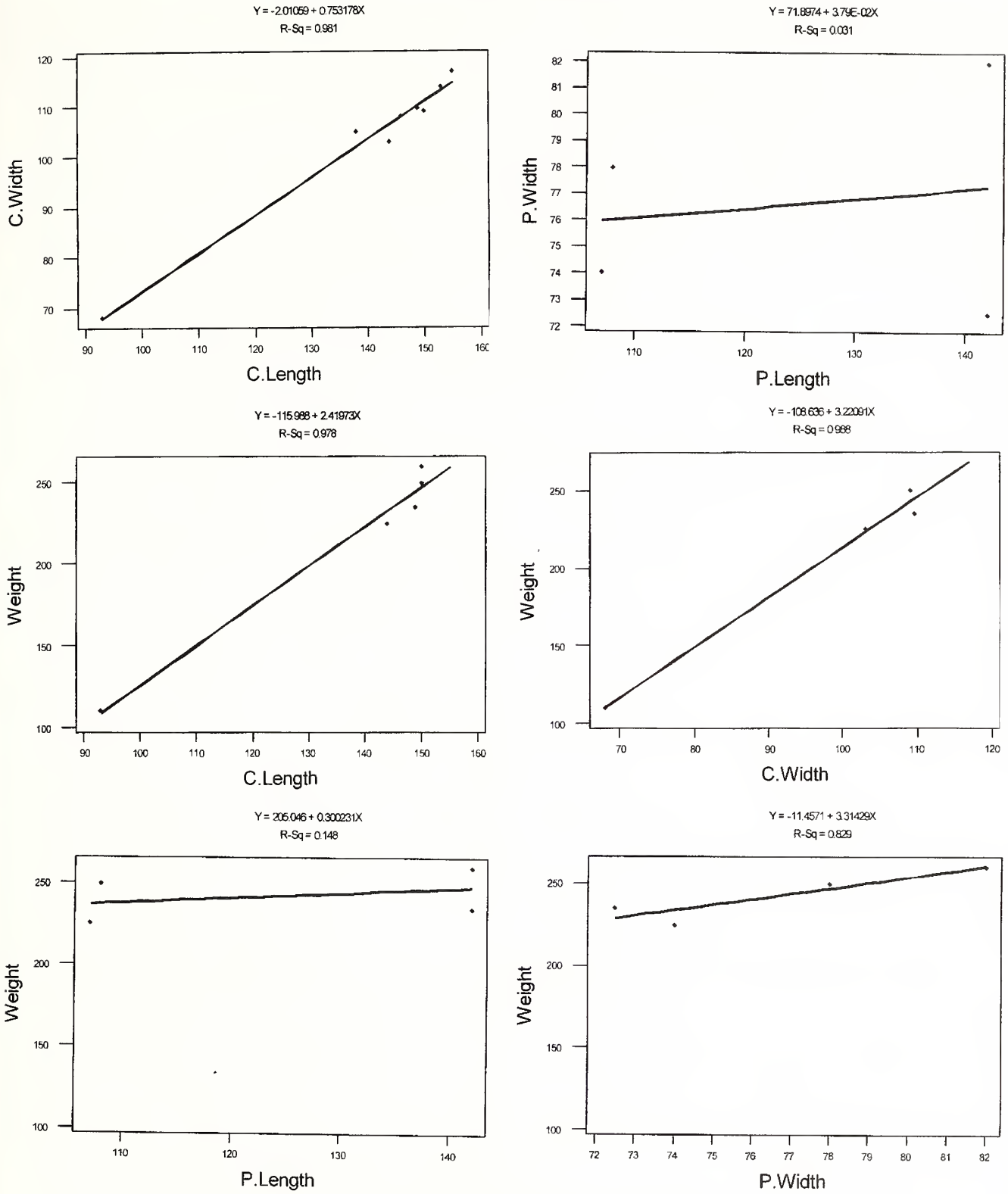

Fig. 4: Regression plots for *Dermochelys coriacea*

both the sexes was observed as 40 kg. Tripathy and Choudhury (2002) reported the curved carapace length of 58.2 cm, width of 48.3, plastron length of 48.4 and plastron width of 43.5 cm of the Green Turtle, which was washed ashore in Andhra Pradesh coast during February 2001. In the present study, the Green turtle carapace length ranged from 43.5-96.0 cm, width 41.0-86.0 cm, plastron length ranged from 36.0-82.0 cm, width 32.0-76.5 cm and weight ranged from

15.0-89.0 kg. Considerably larger Green Turtles were recorded in the present study.

Karbari (1981) reported that the Hawksbill Turtle which landed in Bombay (= Mumbai) had a carapace length 78.3 cm, width 61.3 cm, and weight of 80 kg. Ganapathy (1994) recorded a Hawksbill Turtle washed ashore near Thondi, Tamil Nadu in Palk Bay had a carapace length 45 cm. Bellini *et al.* (2000) observed that the Hawksbill in Sueste Bay in Brazil had a curved carapace length of 74 cm and carapace width of 65 cm. When compared to the previous studies it was noted that slightly smaller sized Hawksbills were recorded during the present observation.

Measurement of the Leatherback Turtle, which was washed ashore in the Gulf of Mannar coast, revealed that the carapace length was 162 cm, width 86 cm, plastron length 150, and width of 87 cm (Krishna and Kasinathan 1989). Hasbún and Vásquez (1999) stated that the average curved carapace length of Leatherback was 158 cm. Godley *et al.* (1998) speculated that the mean curved carapace length of Leatherback Turtle was 152 cm (range 120-210 cm). The sizes of the incidentally captured Leatherback were thought to be of adults or subadults (Boulon *et al.* 1996). When compared with earlier studies, the present study showed that the mean value of carapace length of Leatherback Turtle was 142 cm, which is similar to the study by Godley *et al.* (1998).

James *et al.* (1989) recorded that higher percentage of Olive Ridleys carcasses were in the size group of 61-65 cm carapace length during 1984 and 1993, and 66-70 cm during

Table 5: Regression equation models among the morphometric measurements and weight of *Eretmochelys imbricata*

Variables	N	Regression equation	R^2 (%)	Model F	P
Carapace length vs carapace width	43	Carapace width = 1.08 + 0.82 Carapace length	92.3	490.42	<0.001
Plastron length vs plastron width	43	Plastron width = 3. 28 + 0.80 Plastron length	86.9	272.58	<0.001
Carapace length vs weight	43	Weight = - 22.2 + 0.915 Carapace length	84.2	218.35	<0.001
Carapace width vs weight	43	Weight = - 47.80 + 2.50 Carapace width - 0.018 Carapace width^2	72.1	51.67	<0.001
Plastron length vs weight	43	Weight = - 72.32 + 4.27 Plastron length - 0.043 Plastron length^2	67.4	41.42	<0.001
Plastron width vs weight	43	Weight = - 67.86+4.39 Plastron width -0.0472 Plastron width^2	73.6	55.83	<0.001

Table 6: Regression equation models among the morphometric measurements and weight of *Dermochelys coriacea*

Variables	N	Regression equation	R^2 (%)	Model F	P
Carapace length vs carapace width	8	Carapace width = - 2.01 + 0.753 Carapace length	98.1	306.59	<0.001
Plastron length vs plastron width	4	Plastron width = 71.9 + 0. 38 Plastron Length	3.1	0.06	0.823
Carapace length vs weight	5	Weight = -116 + 2.42 Carapace length	97.8	132.67	<0.001
Carapace width vs weight	4	Weight = -109 + 3.22 Carapace width	98.8	171.01	<0.001
Plastron length vs weight	4	Weight = 205 + 0.300 Plastron length	14.8	0.35	0.615
Plastron width vs weight	4	Weight = 11.5 + 3.31 Plastron width	82.9	9.67	0.009

1985-1987. Regarding carapace width, higher percentage frequency was in the size group 56-60 cm in 1983-1984 and 66-70 cm during 1985-87 seasons. The data on the size group composition of the present study was similar to an earlier study by James *et al.* (1989).

Regression equations were established in the present study between the various morphometric characters of the four species of turtles. Such equations were not attempted earlier. These relationships will be helpful in determining population structure of the turtles from different parts of the world, if such data from those areas is also available for comparison.

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AVIFAUNA OF THE ANDAMAN ISLANDS: PRELIMINARY INVENTORY AND DISTRIBUTIONAL PATTERNS[1]

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The distribution of 78 species of resident birds from 27 families was recorded during a survey of 45 islands in the Andamans. The species richness of birds in each site was recorded by repeated walks along transects until the species accumulation curve reached an asymptote. Species restricted to larger islands were not recorded on smaller islands. The number of species in the different islands groups such as the North, Middle, South and Little Andaman islands, did not differ appreciably. Frugivores and omnivores tended to have a wider distribution than raptors, which tended to be restricted to larger islands. This database will provide a baseline with which to compare species distributions in the future.

Keywords: Andaman islands, avifauna, biodiversity assessment, island biogeography, species distribution

INTRODUCTION

Species on islands are more vulnerable to extinction than those on continents because besides factors such as the small population size of island species and lower chances for immigration or recolonisation of islands, they have usually evolved in isolation in a less complex ecosystem (e.g., with fewer predators, diseases and competitors), and therefore cannot face the multiple threats caused by humans. Many birds endemic to islands have gone extinct due to habitat loss, introduced diseases and introduced species (Pimm *et al.* 1995). Developing biodiversity inventories and monitoring changes in fauna can help to identify rare and threatened species, and those with declining populations.

The Andaman and Nicobar Islands, which lie off mainland India, have a rich biota which is facing serious threats due to increasing human pressure and developmental activities (Whitaker 1985; Saldanha 1989; Pande *et al.* 1991; Davidar *et al.* 1995). Therefore, documentation of the distributional patterns of species will provide information that can be used for immediate conservation action and for monitoring species over time. In this study, we provide information on the patterns of bird distribution in the Andaman Islands and interpret the results in the light of conservation priorities.

Pioneering surveys conducted by Abdulali (1964, 1981) on the avifauna of Andaman and Nicobar Islands helped to set up the foundation for more detailed assessments. Ripley and Beehler (1989) analysed the avifauna from an ornitho-geographical perspective and listed 104 species of breeding birds. These include 18 endemic species and 86 endemic races. Davidar *et al.* (1995, 1996, 2001 and 2002) and Devy *et al.* (1998) conducted ecological surveys of forest birds and butterflies in the Andaman group in the 1990s. They showed that there is a latitudinal gradient in habitat diversity, with the southernmost islands in the Andaman group having a higher proportion of evergreen forests than the northern islands. They demonstrated that island size and the presence of evergreen forests significantly influenced species richness. The larger islands had more species, and rarer species, than did small islands. The avifauna of smaller islands was a nested subset of those on larger islands. Therefore, they suggested that conservation efforts should be focused on protecting forests on large islands, and evergreen forests in particular should be prioritised for conservation efforts.

An ornitho-geographic analysis on the Andaman and Nicobar avifauna was conducted by Ripley and Beehler (1989), who concluded that the avifauna of the Andamans were predominantly allied to that of Myanmar, whereas the Nicobar avifauna was a subset of the avifauna of the Andaman Islands. In this study, we present a preliminary island-wise inventory of the avifauna of the Andaman Islands, with particular emphasis on forest birds. We assessed the proportion of islands on which each species was distributed with regard to island size, location and the smallest island on which it was recorded. We also assessed whether the distribution patterns of foraging guilds differed with regard to island size and location.

STUDY AREA

The Andaman Islands lie between 10° 30'-13° 41' N and 92° 12'-93° 57' E, off the coast of south-east Asia in the

Bay of Bengal. The northernmost islands are about 285 km from Myanmar, and the southernmost is Little Andaman Island, located between the Andaman group and the Nicobars. Most of the land area of the Andamans consists of five large and contiguous islands, North Andaman Island, Middle Andaman Island, Baratang, South Andaman Island and Rutland. The Little Andamans, another large island is about 100 km south of South Andaman island and is separated from the Nicobars, which lie further south by the 140 km wide 10 degree channel.

The climate is tropical and oceanic with rainfall from both the Southwest and Northeast monsoon winds. The average annual rainfall is about 3,000 mm (Pande *et al.* 1991), increasing from the northern to the southern islands (Ellis 1989). This results in a north-south vegetation gradient with predominantly drier forests in the northern islands and wetter forests in the southern islands (Davidar *et al.* 2002). Evergreen forests are usually confined to large and medium sized islands, except towards the south where some small islands have evergreen forest; otherwise most small islands have dry forests (Davidar *et al.* 1995, 2002).

METHODS

Bird survey

The sampling was focused on forest birds, and therefore the sampling effort was concentrated within inland forested habitats, and therefore mangroves, swamps, mudflats and inland waterways, and nocturnal species were under sampled. However, we are including all records in this paper as a database for future reference.

A bird list for each island was compiled based on sightings along line transects. The number of transects depended on the size of the island, and several sites were sampled on the large islands, whereas the entire area was covered in case of small islands. In each site, the number of habitats was assessed and transects were walked in each habitat type in the mornings starting at dawn. A species list for each island was compiled based on the transect walks. All birds seen and heard were recorded and identified using Ali and Ripley (1987), and King *et al.* (1975). Casual sightings of birds were also used to compile the species list of each island.

We placed species in a foraging guild, i.e. insectivore, frugivore, raptor, based on observations and field notes from Ali and Ripley (1987) and Davidar *et al.* (1996). We classified birds of prey as raptors rather than carnivores based on the conventional usage of the term raptors to describe carnivorous birds.

Islands sampled

Forty-five islands in the Andaman group were surveyed during the dry season, from February to May in 1992 and 1993 and in February of 1994. A list of islands surveyed along with their area in sq. km is given in Table 1. This survey covered all the large islands, from North Andaman Island in the north to Little Andaman Island in the south, and most islands in the associated archipelagos (Davidar *et al.* 1995). For details of the survey methodology see earlier publications (Davidar *et al.* 1995, 1996, 2001, 2002).

The South Andamans and the Labyrinth Archipelago were surveyed from February to May 1992. Baratang, Ritchie's archipelago and seven islands off the North Andamans were surveyed from February to May 1993, and North Andaman Island and eleven associated islands were surveyed in February 1994. Little Andaman Island was surveyed in 1992 and 1994.

To facilitate data analysis we categorised the islands by location: the North Andamans, Middle Andamans and Baratang, South Andamans and Little Andaman island. Each island was classified as large (>20 sq. km), medium (10 to 19 sq. km), small (0.1 to 9 sq. km) or very small (<0.1 sq. km). There were 8 large islands, ranging from Peel (23 sq. km) to South Andaman island (>1000 sq. km), 7 medium islands ranging from Tarmugli (11.5 sq. km) to Long (14 sq. km), 25 small islands, ranging from Jolly Buoy (0.12 sq. km) to Paget (4 sq. km), and 5 very small islands (Table 1). We looked at the proportionate occurrence of species on island groups, and different island size categories. The smallest island on which a species tended to occur was noted, and the minimum area requirements for all species were estimated. The species recorded on all island sizes were categorised as "all". We looked at the distribution of species in different foraging guilds with regard to island location and island size.

RESULTS

Our inventory included 78 species of birds belonging to 27 families from 45 islands of different size categories (Appendices 1-3). Thirty of these species were not included in our earlier publications (Davidar *et al.* 1995, 1996, 2001, 2002) because our survey had focused on diurnal forest birds and these additional species were nocturnal species, were not primarily forest dwelling or were wetland avifauna. Some of the rare records were on the North Andaman group of islands.

The species distribution of birds on islands indicated that 20 species were found in fewer than 5 islands, and fewer than 5 species were found on over 40 islands (Fig. 1). Twenty-seven species (34%) were recorded on islands of all size

Table 1: Area in sq.km of the islands surveyed

Island	Area (sq. km)	Island size category
South Andamans	1,348	L
North Andamans	1,128	L
Little Andamans	675	L
Baratang	230	L
Rutland	116	L
Havelock	92	L
John Lawrence	35	L
Peel	23	L
Long	14	M
Wilson	14	M
Landfall	13	M
North Passage	13	M
Sound	12.7	M
Neil	12.6	M
Tarmugli	11.5	M
Paget	4	S
Alexandria	3.6	S
North Reef	3.4	S
Red Skin	3.3	S
East	3	S
Nicholson	1.8	S
North Cinque	1.6	S
Inglis	1.4	S
Guitar	1	S
Point	0.8	S
Malay	0.7	S
Reef	0.6	S
Hugh Rose	0.6	S
Delgarno	0.5	S
Twins	0.44	S
Middle Button	0.4	S
Excelsior	0.4	S
Ross(NA)	0.3	S
Ross(SA)	0.28	S
Pocock	0.25	S
Aves	0.25	S
North Button	0.25	S
Snob	0.22	S
Turtle	0.13	S
Jolly Buoy	0.12	S
Chester	0.09	VS
Curlew	0.07	VS
Temple	0.06	VS
Egg	0.06	VS
Grub	0.03	VS

L-Large, M-Medium, S-Small, VS-Very small

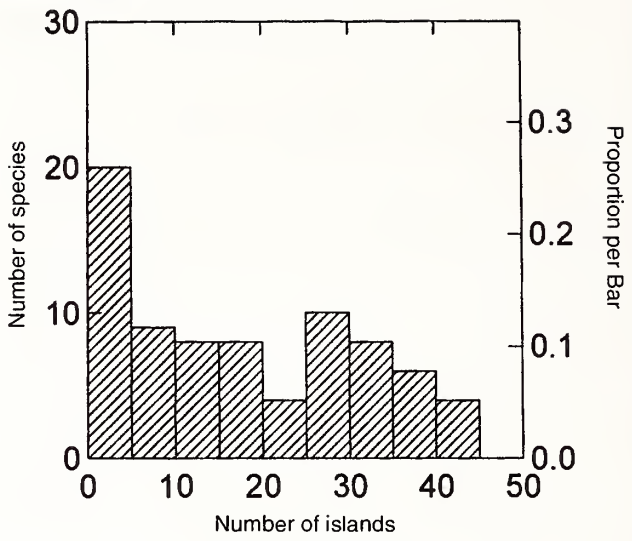

Fig. 1: Bird species distributions on islands

classes (Table 3). The majority of species were restricted to islands of particular size classes (Table 3). Fifty species (64%) were not found on islands <0.1 sq. km in area. Five species (6%) were recorded only on islands >10 sq. km and 11 species (14%) on islands >20 sq. km in area.

The distribution of guilds was strongly influenced by island size rather than by island location (Tables 2 and 4). Similar numbers of species were recorded in the different island groups, but Little Andamans had slightly fewer species than the other island groups, probably because of its isolation. Frugivores and omnivores tended to occur on islands of all sizes (Table 4), whereas raptors tended to be restricted to larger islands. A few species of insectivores and piscivores tended to occur only on large islands (Table 4).

DISCUSSION

Our assessment of bird distributions in the Andaman Islands indicates that the majority of species were restricted to larger than smaller islands. This supports our earlier observations that bird distributions in the Andaman Islands are strongly influenced by island size (Davidar *et al.* 2001). Ripley and Beehler (1989) stated that the avifauna of the Andamans is a subset of that of Myanmar and consists predominantly of widespread colonising species with high dispersal ability. Our study shows that many species do not

Table 2: Number of species of each feeding guild in the four island groups

Island group	Frugivore	Granivore	Insectivore	Nectarivore	Omnivore	Piscivore	Raptor
North	10	4	29	1	5	5	9
South	13	3	29	1	5	6	9
Middle	12	5	29	1	5	6	7
Little	11	2	23	1	4	5	8

Table 3: Percentage of birds of each species recorded on 45 islands of different size classes and minimum area requirements of species

Family/Scientific name	Common name	Island size category				
		Large (>20 sq.km) (N=8)	Medium (10-19 sq.km) (N=7)	Small (0.1 sq.km) (N=25)	Very Small (<0.1 sq.km) (N=5)	Minimum Island area requirements (sq.km)
Accipitridae						
Accipter nisus	Eurasian Sparrow-Hawk	37.5	0	0	0	>20
Accipter virgatus	Besra Sparrow-hawk	100	42.86	12	0	>0.1
Aviceda leuphotes	Black Baza	87.5	42.86	4	0	>0.1
Haliaeetus leucogaster	White-bellied Sea Eagle	100	85.71	44	0	>0.1
Spilornis cheela	Crested Serpent-Eagle	100	71.43	28	0	>0.1
Spilornis elgini	Andaman Serpent-Eagle	100	100	36	12.5	All
Spizaetus cirrhatus	Changeable Hawk-Eagle	87.5	57.14	24	0	>0.1
Alcedinidae						
Alcedo atthis	Common Kingfisher	37.5	0	8	0	>0.1
Todiramphus chloris	Collared Kingfisher	100	100	28	12.5	All
Halcyon coromanda	Ruddy Kingfisher	0	0	24	12.5	All
Halcyon pileata	Black-capped Kingfisher	12.5	0	8	0	>20
Halcyon smyrnensis	White-throated Kingfisher	100	100	84	50	All
Pelargopsis capensis	Stork-billed Kingfisher	100	28.57	24	0	All*
Anatidae						
Anas albogularis	Andaman Teal	50	0	4	0	>0.1
Dendrocygna javanica	Lesser Whistling-duck	25	0	4	0	>0.1
Apodidae						
Hirundapus giganteus	Brown-throated Needletail	100	85.71	20	0	>0.1
Artamidae						
Artamus leucorhynchus	White-breasted Woodswallow	87.5	100	44	0	>0.1
Burhinidae						
Esacus recurvirostris	Great Thick-Knee	0	0	12	0	>0.1
Campephagidae						
Coracina dobsoni	Andaman Cuckooshrike	37.5	0	4	0	>0.1
Coracina macei	Large Cuckooshrike	100	85.71	52	25	All
Pericrocotus speciosus	Scarlet Minivet	100	57.14	28	0	>0.1
Pericrocotus cinnamomeus	Small Minivet	100	85.71	76	12.5	All
Caprimulgidae						
Caprimulgus macrurus	Large-tailed Nightjar	100	14.29	12	12.5	All
Eurostopodus macrotis	Great Eared Nightjar	0	14.29	0	0	>10
Columbidae						
Caloenas nicobarica	Nicobar Pigeon	0	0	4	0	>0.1
Chalcophaps indica	Emerald Dove	100	85.71	48	12.5	All
Columba palumboides	Andaman Wood Pigeon	62.5	42.86	8	0	>0.1
Ducula aenea	Green Imperial Pigeon	100	85.71	68	12.5	All
Ducula bicolor	Pied Imperial Pigeon	50	0	4	0	>0.1
Macropygia rufipennis	Andaman Cuckoo Dove	100	28.57	28	0	>0.1
Streptopelia decaocto	Eurasian Collared-Dove	25	0	0	0	>20
Streptopelia tranquebarica	Red Collared-Dove	12.5	28.57	0	0	>10
Treron chloropterus	Andaman Green-Pigeon	100	100	56	0	>0.1
Coraciidae						
Eurystomus orientalis	Dollarbird	87.5	71.43	16	0	>0.1
Corvidae						
Corvus culminatus	Large-billed Crow	25	28.57	16	0	>0.1
Dendrocitta bayleyi	Andaman Treepie	87.5	14.29	4	0	>0.1
Pachycephala grisola	Mangrove Whistler	100	100	88	12.5	All
Cuculidae						
Cacomantis sonneratii	Banded Bay Cuckoo	12.5	0	0	0	>20
Centropus andamanensis	Andaman Coucal	100	100	68	0	>0.1
Chrysococcyx xanthorhynchus	Violet Cuckoo	50	14.29	0	0	>10
Cuculus micropterus	Indian Cuckoo	100	42.86	4	0	>0.1
Eudynamys scolopacea	Asian Koel	100	85.71	40	0	All*
Dicaeidae						
Dicaeum minullum	Plain Flowerpecker	100	100	64	37.5	All

Table 3: Percentage of birds of each species recorded on 45 islands of different size classes and minimum area requirements of species (*contd.*)

Family/Scientific name	Common name	Island size category				
		Large (>20 sq.km) (N=8)	Medium (10-19 sq.km) (N=7)	Small (0.1 sq.km) (N=25)	Very Small (<0.1 sq.km) (N=5)	Minimum Island area requirements (sq.km)
Dicruridae						
Dicrurus andamanensis	Andaman Drongo	100	57.14	28	0	>0.1
Dicrurus paradiseus	Greater Racket-tailed Drongo	100	100	64	50	All
Irenidae						
Irena puella	Asian Fairy Bluebird	100	100	80	12.5	All
Laniidae						
Lanius cristatus	Brown Shrike	50	0	0	0	>20
Meropidae						
Merops leschenaultii	Chestnut-headed Bee-eater	100	100	60	25	All
Merops philippinus	Blue-tailed Bee-eater	12.5	0	0	0	>20
Monarchinae						
Hypothymis azurea	Black-naped Blue Monarch	100	100	80	25	All
Terpsiphone paradisi	Asian Paradise-Flycatcher	50	14.29	4	0	>0.1
Muscicapidae						
Copsychus malabaricus	White-rumped Shama	75	57.14	4	0	>0.1
Copsychus saularis	Oriental Magpie Robin	100	100	92	37.5	All
Muscicapa dauurica	Asian Brown Flycatcher	12.5	14.29	4	0	>0.1
Nectarinidae						
Cinnyris jugularis	Olive-backed Sunbird	100	100	96	62.5	All
Oriolidae						
Oriolus xanthornus	Black-hooded Oriole	62.5	0	0	0	>20
Oriolus chinensis	Black-naped Oriole	100	100	92	12.5	All
Picidae						
Dryocopus hodgei	Andaman Woodpecker	100	71.43	20	0	>0.1
Dryocopus javanensis	White-bellied Woodpecker	100	71.43	24	0	>0.1
Dendrocopus macei	Fulvous-breasted Pied Woodpecker	100	100	60	0	All*
Ploceidae						
Lonchura striata	White-rumped Munia	37.5	28.57	0	0	>10
Psittacidae						
Loriculus vernalis	Vernal Hanging Parrot	100	100	80	50	All
Psittacula alexandri	Red-breasted Parakeet	100	100	32	12.5	All
Psittacula eupatria	Alexandrine Parakeet	100	85.71	64	12.5	All
Psittacula longicauda	Long-tailed Parakeet	100	85.71	60	0	>0.1
Pycnonotidae						
Pycnonotus atriceps	Black-headed Bulbul	87.5	42.86	4	0	>0.1
Pycnonotus jocosus	Red-whiskered Bulbul	100	100	96	62.5	All
Rallidae						
Amaurornis pheonicurus	White-breasted Waterhen	25	0	0	0	>20
Rallina canningi	Andaman Crake	12.5	0	0	0	>20
Strigidae						
Ninox scutulata	Brown Hawk Owl	50	0	0	0	>20
Tyto alba	Barn Owl	25	0	0	12.5	>20
Sturnidae						
Aplonis panayensis	Asian Glossy Starling	100	85.71	56	0	>0.1
Gracula religiosa	Common Hill Myna	100	85.71	56	0	>0.1
Sturnia erythropygia	Andaman White-headed Starling	100	100	72	12.5	All
Sylviinae						
Cettia pallidipes	Pale-footed Bush-Warbler	62.5	14.29	4	0	>0.1
Turdinae						
Saxicola torquatus	Common Stonechat	0	0	4	0	>10
Zoothera citrina	Orange-headed Thrush	75	71.43	56	0	>0.1
Zosteropidae						
Zosterops palpebrosus	White-eye	100	100	92	12.5	All

*Species recorded in casual sightings on all islands (Davidar pers. obs.)

Table 4: Smallest island size (sq. km) in which the different feeding guilds were recorded

Feeding category	Island size			
	>20 sq. km	>10 sq. km	>0.1 sq. km	All islands
Frugivore	0	0	7	6
Granivore	1	2	1	1
Insectivore	4	3	17	9
Nectarivore	0	0	0	1
Omnivore	0	0	2	2
Piscivore	3	0	5	5
Raptor	3	0	5	1

occur on smaller islands, probably due to the absence of their preferred habitat. The avifauna on the small and very small islands tends to consist of vagrants that are widely distributed across all habitat types (Davidar *et al.* 1995, 2001, 2002; Yoganand and Davidar 2000).

The restricted distribution of many species might be due to low dispersal ability or the inability of smaller islands to support viable populations of certain species. The raptors that are at the top of the food chain, and occur at lower densities, were less common on smaller islands (Thiollay 1997). It is quite possible that small islands are not able to support viable populations of raptors, whereas frugivores that depend on a resource that is spatially and temporally unpredictable were widely distributed on islands of all sizes. Frugivores tend to be very mobile and fly over large distances in search of fruiting trees.

Certain species were only recorded on large islands, regardless of feeding category. These species might be specialised to particular habitats found predominantly on larger islands, such as the wet evergreen forests. We found that many species, such as *Columba palumboides*, *Macropygia rufipennis*, *Treron pompadora* and *Gracula religiosa* were associated with wet evergreen forests (Yoganand and Davidar 2000), and are therefore not likely to be recorded on smaller islands that tend to have scrubby or dry vegetation.

In conclusion, assessing the distributions of birds on islands can provide insights into the factors that govern their distribution. This database can provide baseline information with which to record changes in species distributions in the future, and thus has enormous importance for conservation.

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Appendix 1: Distribution of avifauna in the North Andaman island group. Islands are arranged in a descending order of size, from left to right

Family / Scientific name	North Andaman Island Group																
	North Andaman	Landfall	Sound	Paget	North Reef	East	Point	Reef	Delgarno	Excelsior	Ross (NA)	Pocock	Aves	Turtle	Curlew	Temple	Egg
Accipitridae																	
Accipter nisus	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Accipter virgatus	1	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0
Aviceda leuphotes	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Haliaeetus leucogaster	1	1	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0
Spilornis cheela	1	1	0	1	0	1	1	0	0	0	1	0	0	0	0	0	0
Spilornis elgini	1	1	1	1	0	1	1	0	1	0	0	0	0	0	0	1	0
Spizaetus cirrhatus	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0
Alcedinidae																	
Todirhamphus chloris	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Halcyon smyrnensis	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Halcyon capensis	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Anatidae																	
Anas albogularis	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dendrocygna javanica	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Apodidae																	
Hirundapus giganteus	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Artamidae																	
Artamus leucorhynchus	0	1	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0
Campephagidae																	
Coracina macei	1	1	1	1	0	1	1	1	0	0	0	0	0	0	1	1	0
Pericrocotus cinnamomeus	1	1	0	0	1	1	1	0	1	0	1	1	1	0	0	0	0
Pericrocotus speciosus	1	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0
Caprimulgidae																	
Caprimulgus macrurus	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
*Eurostopodus macrotis**	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Columbidae																	
Chalcophaps indica	1	0	1	1	0	0	1	1	0	0	0	0	0	0	0	0	0
Ducula aenea	1	1	0	1	0	1	1	0	1	0	1	1	0	0	0	0	0
Ducula bicolor	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Macropygia rufipennis	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Streptopelia decaocto	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Treron chloropterus	1	1	1	1	0	1	1	0	1	0	1	1	0	0	0	0	0
Coraciidae																	
Eurystomus orientalis	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Corvidae																	
Dendrocitta bayleyi	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pachycephala grisola	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	0	0
Cuculidae																	
Cacomantis sonneratii	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Centropus andamanensis	1	1	1	1	1	0	1	1	1	1	0	0	0	0	0	0	0
Chrysococcyx xanthorhynchus	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cuculus micropterus	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eudynamys scolopacea	1	1	0	1	0	0	1	0	1	0	1	0	0	0	0	0	0
Dicaeidae																	
Dicaeum minullum	1	1	1	1	0	1	1	0	1	0	1	1	0	1	1	1	1

Appendix 1: Distribution of avifauna in the North Andaman island group. Islands are arranged in a descending order of size, from left to right (*contd.*)

Family / Scientific name	North Andaman Island Group																
	North Andaman	Landfall	Sound	Paget	North Reef	East	Point	Reef	Delgarno	Excelsior	Ross (NA)	Pocock	Aves	Turtle	Curlew	Temple	Egg
Dicruridae																	
Dicrurus andamanensis	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0
Dicrurus paradiseus	1	1	1	1	0	1	1	1	1	0	0	0	0	0	1	0	1
Irenidae																	
Irena puella	1	1	1	1	0	1	1	1	1	1	1	1	0	0	0	0	0
Meropidae																	
Merops leschenaultii	1	1	1	1	0	1	1	1	1	1	0	0	0	0	0	0	0
Merops philippinus	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Monarchinae																	
Hypothymis azurea	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	1	0
Muscicapidae																	
Copsychus saularis	1	1	1	1	1	1	1	1	1	1	0	0	1	1	1	0	0
*Muscicapa dauurica**	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Nectarinidae																	
Cinnyris jugularis	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1
Oriolidae																	
Oriolus chinensis	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0
Oriolus xanthornus	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Picidae																	
Dryocopus hodgei	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dryocopus javanensis	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Dendrocopos macei	1	1	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0
Ploceidae																	
*Lonchura striata**	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Psittacidae																	
Loriculus vernalis	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1
Psittacula alexandri	1	1	1	0	0	1	1	0	0	0	0	0	0	0	1	0	0
Psittacula eupatria	1	0	1	1	0	0	1	0	1	0	1	1	1	1	0	1	0
Psittacula longicauda	1	1	0	1	0	1	1	1	1	0	0	0	0	0	0	0	0
Pycnonotidae																	
Pycnonotus jocosus	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1
Pycnonotus atriceps	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Strigidae																	
Ninox scutulata	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
*Tyto alba**	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sturnidae																	
Aplonis panayensis	1	1	0	1	0	0	1	0	1	1	1	0	1	0	0	0	0
Gracula religiosa	1	1	0	0	0	1	1	1	1	0	1	1	0	1	0	0	0
Sturnia erythropygia	1	1	1	1	1	1	1	1	1	1	0	1	1	0	1	0	0
Turdinae																	
Saxicola torquata	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Zoothera citrina	1	0	0	1	0	0	1	1	1	1	0	0	0	0	0	0	0
Zosteropidae																	
Zosterops palpebrosus	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0

* - Species recorded during casual sightings on all islands (Davidar pers. obs.)

Appendix 2: Distribution of avifauna in the South Andaman island group. Islands are arranged in a descending order of size, from left to right

Family / Scientific name	South Andaman Island Group													
	South Andamans	Little Andaman	Rutland	Tarmugli	Alexandra	Redskin	North Cinque	Malay	Twins	Ross (SA)	Snob	Jolly Buoy	Chester	Grub
Accipitridae														
Accipter nisus	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Accipter virgatus	1	1	1	1	0	0	0	0	0	0	0	0	0	0
Aviceda leuphotes	1	1	1	0	0	0	0	0	0	0	0	0	0	0
Haliaeetus leucogaster	1	1	1	1	1	1	0	1	0	1	0	0	0	0
Spilornis cheela	1	1	1	0	0	1	0	0	0	0	0	0	0	0
Spilornis elgini	1	1	1	1	1	1	1	1	0	0	0	0	0	0
Spizaetus cirrhatus	1	1	1	1	1	1	1	0	0	0	0	0	0	0
Alcedinidae														
Alcedo atthis	1	0	1	0	1	0	0	0	0	0	0	1	0	0
Todirhamphus chloris	1	1	1	1	1	1	0	1	1	1	0	0	1	0
Halcyon coromanda	0	0	0	0	1	1	0	1	1	1	1	0	1	0
Halcyon pileata	0	0	0	0	0	1	0	0	0	0	1	0	0	0
Halcyon smyrnensis	1	1	1	1	1	1	0	1	1	1	1	1	1	0
Halcyon capensis	1	1	1	0	1	1	1	0	0	1	0	0	0	0
Anatidae														
Anas albogularis	1	0	0	0	0	1	0	0	0	0	0	0	0	0
Dendrocygna javanica	1	0	0	0	0	1	0	0	0	0	0	0	0	0
Apodidae														
Hirundapus giganteus	1	1	1	1	1	1	0	0	0	0	0	0	0	0
Artamidae														
Artamus leucorhynchus	1	1	1	1	1	0	1	0	1	1	0	0	0	0
Campephagidae														
Coracina macei	1	1	1	1	1	1	1	1	0	0	1	0	0	0
Coracina dobsoni	1	0	1	0	1	0	0	0	0	0	0	0	0	0
Pericrocotus cinnamomeus	1	1	1	1	1	1	1	0	1	1	1	1	0	1
Pericrocotus speciosus	1	1	1	1	1	1	0	1	0	0	0	0	0	0
Caprimulgidae														
Caprimulgus macrurus	1	1	1	0	1	1	0	0	0	0	0	0	0	1
Columbidae														
Caloenas nicobarica	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Chalcophaps indica	1	1	1	1	1	1	1	0	0	1	1	1	1	0
Columba palumboides	1	0	1	1	1	0	0	0	0	0	0	0	0	0
Ducula aenea	1	1	1	1	1	1	1	1	1	0	1	0	0	1
Ducula bicolor	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Macropygia rufipennis	1	1	1	0	1	1	1	1	0	0	1	0	0	0
Treron chloropterus	1	1	1	1	1	1	0	1	0	0	1	0	0	0
Coraciidae														
Eurystomus orientalis	1	1	1	1	1	1	0	0	0	0	1	0	0	0
Corvidae														
Corvus culminatus	0	0	0	0	1	1	0	0	0	0	0	1	0	0
Dendrocitta bayleyi	1	1	1	0	1	0	0	0	0	0	0	0	0	0
Pachycephala grisola	1	1	1	1	1	1	1	1	0	0	1	1	1	0

Appendix 2: Distribution of avifauna in the South Andaman island group. Islands are arranged in a descending order of size, from left to right (*contd.*)

Family / Scientific name	South Andaman Island Group													
	South Andamans	Little Andaman	Rutland	Tarmugli	Alexandra	Redskin	North Cinque	Malay	Twins	Ross (SA)	Snob	Jolly Buoy	Chester	Grub
Cuculidae														
Centropus andamanensis	1	1	1	1	1	1	1	1	0	1	1	1	0	0
Chrysococcyx xanthorhynchus	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Cuculus micropterus	1	1	1	1	1	0	0	0	0	0	0	0	0	0
Eudynamys scolopacea	1	1	1	1	1	1	0	1	0	1	1	0	0	0
Dicaeidae														
Dicaeum minullum	1	1	1	1	1	1	0	1	0	0	1	1	0	0
Dicruridae														
Dicrurus andamanensis	1	1	1	1	1	1	1	0	0	0	1	0	0	0
Dicrurus paradiseus	1	1	1	1	1	1	1	1	0	1	1	1	1	1
Irenidae														
Irena puella	1	1	1	1	1	1	1	0	1	1	1	0	1	0
Laniidae														
Lanius cristatus	1	1	1	0	0	0	0	0	0	0	0	0	0	0
Meropidae														
Merops leschenaultii	1	1	1	1	1	1	1	0	1	1	1	0	1	1
Monarchinae														
Hypothymis azurea	1	1	1	1	1	1	1	1	0	0	1	1	1	0
Terpsiphone paradisi	1	0	1	0	1	0	0	0	0	0	0	0	0	0
Muscicapidae														
Copsychus malabaricus	1	1	1	1	1	0	0	0	0	0	0	0	0	0
Copsychus saularis	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Nectarinidae														
Cinnyris jugularis	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Oriolidae														
Oriolus chinensis	1	1	1	1	1	1	1	1	1	1	1	1	1	0
Oriolus xanthornus	1	0	1	0	0	0	0	0	0	0	0	0	0	0
Picidae														
Dryocopus hodgei	1	1	1	1	1	1	0	1	0	0	0	1	0	0
Dryocopus javanensis	1	1	1	1	1	1	0	1	0	0	0	1	0	0
Dendrocopos macei	1	1	1	1	1	1	1	1	0	1	1	0	0	0
Ploceidae														
*Lonchura striata**	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Psittacidae														
Loriculus vernalis	1	1	1	1	1	1	1	1	0	0	0	1	1	0
Psittacula alexandri	1	1	1	1	1	1	1	0	0	1	1	0	0	0
Psittacula eupatria	1	1	1	1	1	1	1	1	1	0	1	0	0	0
Psittacula longicauda	1	1	1	1	1	1	0	1	1	0	0	0	0	0
Pycnonotidae														
Pycnonotus jocosus	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Pycnonotus atriceps	1	1	1	0	0	0	0	0	0	0	0	0	0	0

Appendix 2: Distribution of avifauna in the South Andaman island group. Islands are arranged in a descending order of size, from left to right (*contd.*)

Family / Scientific name	South Andaman Island Group													
	South Andamans	Little Andaman	Rutland	Tarmugli	Alexandra	Redskin	North Cinque	Malay	Twins	Ross (SA)	Snob	Jolly Buoy	Chester	Grub
Rallidae														
Amaurornis pheonicurus	1	1	0	0	0	0	0	0	0	0	0	0	0	0
*Rallina canningi**	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Strigidae														
Ninox scutulata	1	1	0	0	0	0	0	0	0	0	0	0	0	0
*Tyto alba**	1	0	0	0	0	0	0	0	0	0	0	0	0	1
Sturnidae														
Aplonis panayensis	1	1	1	1	1	1	1	0	0	1	1	0	0	0
Gracula religiosa	1	1	1	1	1	1	1	1	0	0	1	0	0	0
Sturnia erythropygia	1	1	1	1	1	1	1	0	0	0	0	0	0	0
Sylviinae														
Cettia pallidipes	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Turdinae														
Zoothera citrina	1	0	1	1	0	1	1	1	1	0	1	1	0	0
Zosteropidae														
Zosterops palpebrosus	1	1	1	1	1	1	1	1	1	0	0	1	0	0

* - Species recorded in casual sightings on all islands (Davidar pers. obs.)

Appendix 3: Distribution of avifauna in the Middle Andaman island group. Islands are arranged in a descending order of size, from left to right

Family/Scientific name	Middle Andaman Island Group													
	Baratang	Havelock	John Lawrence	Peel	Long	Wilson	North Passage	Neil	Nicholson	Inglis	Guitar Button	Sir Hugh Rose Button	Middle	North
Accipitridae														
Accipter virgatus	1	1	1	1	1	0	0	1	0	0	0	0	0	0
Aviceda leuphotes	1	1	1	0	1	0	1	1	0	0	1	0	0	0
Haliaeetus leucogaster	1	1	1	1	1	0	1	1	1	0	1	0	1	1
Spilornis cheela	1	1	1	1	1	1	1	1	1	0	0	1	0	0
Spilornis elgini	1	1	1	1	1	1	1	1	0	0	1	0	0	0
Spizaetus cirrhatus	1	1	1	0	1	0	1	1	0	0	0	0	1	0
Alcedinidae														
Alcedo atthis	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Todirhamphus chloris	1	1	1	1	1	1	1	1	0	1	0	1	0	0
Halcyon smyrnensis	1	1	1	1	1	1	1	1	1	0	1	1	0	0
Halcyon capensis	1	1	1	1	1	0	0	1	0	0	0	1	0	1
Anatidae														
Anas albugularis	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Apodidae														
Hirundapus giganteus	1	1	1	1	1	1	1	1	0	1	1	1	0	0

Appendix 3: Distribution of avifauna in the Middle Andaman island group. Islands are arranged in a descending order of size, from left to right (*contd.*)

Family/Scientific name	Middle Andaman Island Group													
	Baratang	Havelock	John Lawrence	Peel	Long	Wilson	North Passage	Neil	Nicholson	Inglis	Guitar Button	Sir Hugh Rose Button	Middle	North
Artamidae														
Artamus leucorhynchus	1	1	1	1	1	1	1	1	0	1	1	1	1	1
Burhinidae														
Esacus recurvirostris	0	0	0	0	0	0	0	0	0	1	0	0	1	1
Campephagidae														
Coracina macei	1	1	1	1	1	1	1	0	1	1	1	0	1	0
Coracina dobsoni	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Pericrocotus cinnamomeus	1	1	1	1	1	1	1	1	1	1	1	1	1	0
Pericrocotus speciosus	1	1	1	1	1	1	1	0	1	0	1	0	0	0
Caprimulgidae														
Caprimulgus macrurus	1	1	1	1	1	0	0	0	0	0	0	0	0	0
Columbidae														
Chalcophaps indica	1	1	1	1	1	1	1	1	0	1	0	1	1	0
Columba palumboides	1	1	1	0	1	0	0	1	1	0	0	0	0	0
Ducula aenea	1	1	1	1	1	1	1	1	1	1	1	0	1	1
Ducula bicolor	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Macropygia rufipennis	1	1	1	1	1	1	0	0	1	0	0	0	0	0
Streptopelia decaocto	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Streptopelia tranquebarica	0	0	0	0	1	0	0	1	0	0	0	0	0	0
Treron chloropterus	1	1	1	1	1	1	1	1	1	1	0	1	1	0
Coraciidae														
Eurystomus orientalis	1	1	1	0	1	1	1	1	0	0	0	0	0	0
Corvidae														
Corvus culminatus	0	1	0	0	1	1	0	0	1	0	0	0	0	0
Dendrocitta bayleyi	1	1	1	0	1	0	0	0	0	0	0	0	0	0
Pachycephala griseola	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Cuculidae														
Centropus andamanensis	1	1	1	1	1	1	1	1	1	1	0	0	1	1
Chrysococcyx xanthorhynchus	0	1	1	0	1	0	0	0	0	0	0	0	0	0
Cuculus micropterus	1	1	1	1	1	0	1	0	0	0	0	0	0	0
Eudynamys scolopacea	1	1	1	1	1	1	1	1	0	0	0	1	0	0
Dicaeidae														
Dicaeum minullum	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Dicruridae														
Dicrurus andamanensis	1	1	1	1	1	1	1	0	1	0	0	0	0	0
Dicrurus paradiseus	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Irenidae														
Irena puella	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Laniidae														
Lanius cristatus	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Meropidae														
Merops leschenaultii	1	1	1	1	1	1	1	1	0	0	1	0	1	1

Appendix 3: Distribution of avifauna in the Middle Andaman island group. Islands are arranged in a descending order of size, from left to right (*contd.*)

Family/Scientific name	Middle Andaman Island Group													
	Baratang	Havelock	John Lawrence	Peel	Long	Wilson	North Passage	Neil	Nicholson	Inglis	Guitar Button	Sir Hugh Rose Button	Middle	North
Monarchinae														
Hypothymis azurea	1	1	1	1	1	1	1	1	1	1	1	1	1	0
Terpsiphone paradisi	0	1	0	0	0	0	0	1	0	0	0	0	0	0
Muscicapidae														
Copsychus malabaricus	1	1	1	0	1	0	1	1	0	0	0	0	0	0
Copsychus saularis	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Nectarinidae														
Cinnyrus jugularis	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Oriolidae														
Oriolus chinensis	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Oriolus xanthornus	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Picidae														
Dryocopus hodgei	1	1	1	1	1	1	1	0	1	0	0	0	0	0
Dryocopus javanensis	1	1	1	1	1	1	1	0	1	0	0	0	0	0
Dendrocopos macei	1	1	1	1	1	1	1	1	1	1	1	0	1	0
Ploceidae														
*Lonchura striata**	0	0	0	1	1	0	0	1	0	0	0	0	0	0
Psittacidae														
Loriculus vernalis	1	1	1	1	1	1	1	1	1	1	1	1	1	0
Psittacula alexandri	1	1	1	1	1	1	1	1	0	1	0	0	0	0
Psittacula eupatria	1	1	1	1	1	1	1	1	1	1	1	0	0	0
Psittacula longicauda	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Pycnonotidae														
Pycnonotus jocosus	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Pycnonotus atriceps	1	1	1	0	1	1	1	0	0	0	1	0	0	0
Strigidae														
Ninox scutulata	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Sturnidae														
Aplonis panayensis	1	1	1	1	1	1	1	1	1	1	1	0	0	0
Gracula religiosa	1	1	1	1	1	1	1	1	1	0	1	0	0	0
Sturnus erythropygius	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Sylviinae														
Cettia pallidipes	1	1	1	1	1	0	0	0	1	0	0	0	0	0
Turdinae														
Zoothera citrina	1	1	1	0	1	1	1	1	1	0	0	0	1	1
Zosteropidae														
Zosterops palpebrosus	1	1	1	1	1	1	1	1	1	1	1	1	1	1

* - Species recorded during casual sightings on all islands (Davidar pers. obs.)

FAUNAL DIVERSITY IN PRAWNS AND CRABS IN DIGHA AND ADJACENT COAST IN WEST BENGAL WITH NOTES ON THE RELATIONSHIP OF THEIR ABUNDANCE WITH PHYSICO-CHEMICAL PARAMETERS[1]

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Studies on the diversity of prawns and crabs in Digha and its adjacent coast in West Bengal, which are rich in fauna, were carried out from April 2000-December 2005. Twenty-four species of prawns, two species of lobsters, twenty three species of brachyuran crabs and fourteen species of anomuran crabs were recorded. Attempts were also made to determine the relationship of the abundance of some species with the physico-chemical parameters.

Key words: prawns, crabs, diversity, Digha coast, abundance, physico-chemical parameters

INTRODUCTION

Chandrasekhara Rao and Misra (1986) made a preliminary investigation on the distribution and ecology of the intertidal fauna of Digha Beach located in West Bengal. They studied the composition, density and distribution of the meiofauna and macrofauna of this beach during 1979-1980. This paper aims at giving a detailed account of the diversity in prawns and crabs found on Digha beach, based on studies conducted from April 2000 to December 2005. Attempts have also been made to correlate the abundance of these animals with some physico-chemical parameters.

A variety of prawns and one species of lobster belonging to the genus *Panulirus* dominate Digha and the adjacent coast. The important species of prawn include *Penaeus monodon*, *Penaeus indicus*, *Penaeus merguiensis*, *Penaeus semisulcatus*, *Metapenaeus monoceros*, *Metapenaeus brevicornis* and *Macrobrachium rosenbergii*.

Crabs constitute one of the most dominant macrobenthic faunal components in the ecosystem; they play several significant roles. The feeding activities of detritivore crabs, particularly of the genera *Uca*, *Macrophthalmus*, *Dotilla*, *Sesarma*, and *Metaplax* help in the degradation of plant matter to detritus particles, and they are themselves preyed upon by a number of predators such as fish, reptiles, birds and mammals. The crabs also have a positive effect on the brackish water zone of mangrove ecosystem, due to their burrowing activities, the aeration of soil increases. Another important role of crabs in mangrove environments is the production of millions of meroplankton which serve as potential source of food for a wide variety of planktophagous organisms, including a rich fish population.

MATERIAL AND METHODS

The present study is based on monthly collection of samples from April 2000 to December 2005 in Digha and the adjacent coast. Digha is situated close to the mouth of the Ganga at 21° 36' N and 87° 30' E. Samples were collected using shrimp seed collection nets (shoot nets) from the following locations: 1) Paschim Gadadharpur, about 6 km west of Digha, 2) Udaipur, about 5 km west of Digha, 3) Ongaria Ghat, about 3 km west from Digha, 4) Jatranala Ghat, about 3 km west of Digha and 5) New Digha, about 2 km west of Digha. The prawns and crabs were counted from the beach collections and Drag net hauls. Buried crabs were collected from sand flats during low tide. Specimens were collected using a square metallic frame of 25 x 25 cm, which was 5 cm deep. The quadrant was pushed into the sediment and the enclosed deposit dug out. This process was repeated at the same spot to get another 5 cm layer of sediment below the top 5 cm of deposit.

RESULTS

Coastal West Bengal has a rich crustacean fauna in inshore (including estuaries and mangroves) and offshore waters. Around Digha, 26 species of prawns and 37 species of crabs were recorded (Tables 1 and 2). The prawns belong to three families, Penaeidae, Palaemonidae and Sergestidae. The penaeids form the bulk of the crustacean catch, contributing more than 50% of the total production. In the last two decades, crabs have emerged as an important commodity of export. Apart from prawns and crabs, there is a great demand for lobsters, especially in the international market.

Prawns constitute a large group of crustaceans varying in size from microscopic to about 35 cm long. Nearly 2,500

species are known (FAO 1984). The body is almost always laterally compressed, the rostrum usually compressed and toothed, and the abdomen longer than the carapace. The antennules in most species bear a small scale or spine, the stylocerite, at their base, and the antennal scales of the second pair of feelers, the antennae, are generally large and plate-like. The pereopods or legs are usually slender, but in some species a single leg or a pair of legs may be stout, and some pereopods (the chelipeds) end in pincers or chelae. The pleopods are well developed and usually present on all the five anterior abdominal segments.

Prawns are widely distributed, occurring in marine, brackish and freshwater bodies from the equator to the polar regions. Many are pelagic, but the majority are by far benthic, living on a large variety of bottoms such as rock, mud, peat, sand, fragments of shells or mixtures of these materials. Twenty-four species of prawns and two species of lobsters were recorded from the Digha coast (Table 1). These species

Table 1: List of Prawn and Lobster species recorded from Digha Coast

Prawns
Family: Penaeidae
Metapenaeus affinis (Milne-Edwards)
Metapenaeus brevicornis (Milne-Edwards)
Metapenaeus dobsoni (Miers)
Metapenaeus lysianassa (de Man)
Metapenaeus monoceros (Fabricius)
Parapaenaeopsis sculptilis (Heller)
Parapaenaeopsis stylifera (Milne-Edwards)
Penaeus indicus (Milne-Edwards)
Penaeus japonicus (Bate)
Penaeus merguiensis (de Man)
Penaeus monodon (Fabricius)
Penaeus penicillatus (Alcock)
Penaeus semisulcatus (de Man)

Family: Sergestidae
Acetes erythrina (Nobili)
Acetes indicus (Milne-Edwards)

Family: Palaemonidae
Exopalaemon styliferus (Milne-Edwards)
Macrobrachium equidens (Dana)
Macrobrachium javanicum (Heller)
Macrobrachium lamarrei (Milne-Edwards)
Macrobrachium malcomsonii (Milne-Edwards)
Macrobrachium rosenbergii (de Man)
Macrobrachium rude (Heller)

Family: Hippolytidae
Hippolysmata (*Exhippolysmata*) *ensirostris* (Kemp)
Alpheus malabaricus Fabricius

Lobsters
Family: Palinuridae
Panulirus ornatus (Fabricius)
Thenus orientallis (Lund)

Table 2: List of Crab species recorded from Digha coast

Brachyuran Crabs (True Crabs)
Family: Leucosiidae
Philyra syndactyla (Ortmann)

Family: Calappidae
Matuta lunaris (Hilgendorf)
Matuta planipes (Fabricius)
Calappa lophos (Herbst)

Family: Majidae
Doclea canalifera (Stimpson)
Doclea ovis (Fabricius)

Family: Parthenopidae
Parthenope (*Platylambrus*) *prensor* (Herbst)

Family: Xanthidae
Galene bispinosa (Herbst)

Family: Ocypodidae
Ocypode macrocera (Milne-Edwards)
Uca (*Deltuca*) *rosea* (Tweedie)
Uca dussumieri (Milne-Edwards)
Uca lactea (de Hann)
Uca triangularis (Milne-Edwards)
Dotilla blanfordi Alcock

Family: Portunidae
Scylla serrata (Forskal)
Portunus (*Portunus*) *pelagicus* (Linnaeus)
Portunus (*Portunus*) *sanguinolentus* (Herbst)
Charybdis (*Charybdis*) *rostrata* (Milne-Edwards)
Charybdis (*Charybdis*) *affinis* (Dana)
Charybdis (*Charybdis*) *natator* (Herbst)
Charybdis (*Charybdis*) *feriatus* (Linnaeus)

Family: Grapsidae
Varuna litterata (Fabricius)
Metaplax dentipes (Heller)

Anomuran Crabs (Hermit Crabs)
Family: Diogenidae
Clibanarius clibanarius (Herbst)
Clibanarius infraspinatus (Heligendorf)
Clibanarus padavensis (de Man)
Clibanarus olivaceus (Henderson)
Diogenes custos (Fabricius)
Diogenes affinis (Henderson)
Diogenes planimanus (Henderson)
Diogenes avarus (Heller)
Diogenes costatus (Henderson)
Diogenes investigatoris (Alcock)
Diogenes diogenes (Herbst)
Diogenes miles (Hersbt)
Diogenes rectimanus (Miers)

Family: Coenobitidae
Coenobita cavipes (Stimpson)

are abundant from June to August, with the peak in July. Coastal aquaculture of prawns and other crustaceans is commonly practiced in the region. The demand for prawns in the world market is rapidly increasing. India has rich crustacean resources which are exploited for export.

Lobsters

Lobsters include a variety of crustaceans ranging in size from a few centimeters to more than 60 cm. They are more or less elongate animals with cylindrical and flattened bodies, and a prominent tail or abdomen consisting of six movable segments and a terminal fan.

DISCUSSION

The mean monthly values of the physico-chemical parameters recorded in the study area from April 2000 to December 2005 are given in Fig. 1. The monthly abundance of four prawn and crab species during 2001 and 2004 are given in Fig. 2 and Fig. 3 respectively. The density and diversity of macrofauna on Digha Beach is rich, due to the

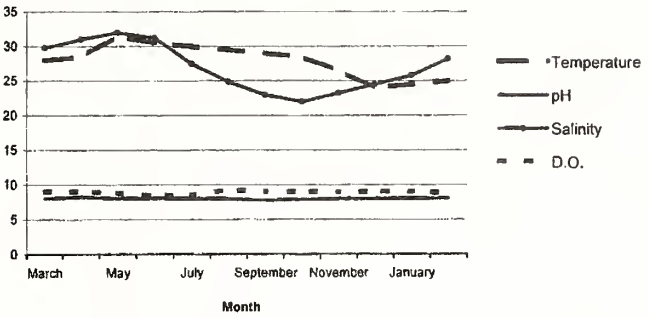

Fig. 1: Average temperature, pH, salinity, dissolved oxygen (D.O.), recorded from the study area during the study period (April 2000-December 2005)

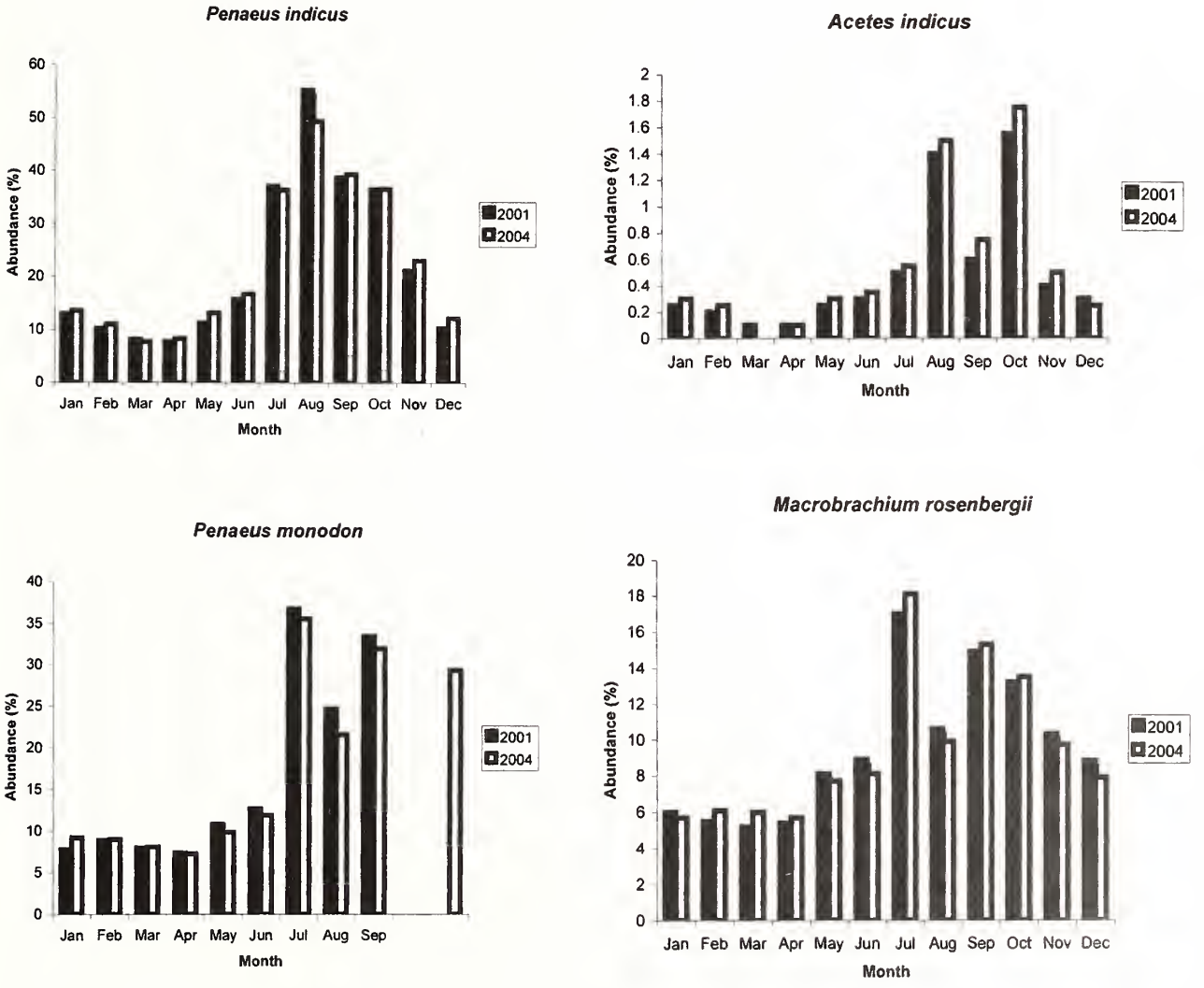

Fig. 2: Comparative chart showing monthly abundance of four prawn species recorded from the study area during 2001 and 2004

relatively sheltered sand flat rich in organic detritus. Due to the fine nature of the substratum, the majority of the species colonising the beach are deposit and filter feeders (Chandrasekhara Rao and Misra 1986). The abundant occurrence of *Donax-Odostomia* populations in the middle of the beach is probably related to the abundant supply of detritus on the beach. Fine intertidal deposits are also known to support rich populations of microorganisms forming food for bivalves. The patchy distribution of macrofauna on the beach seems to be due to the environmental preferences and tolerances of the component species (McIntyre 1969). The macrofauna shows some submergence in the beach towards higher tidal levels, apparently seeking optimum conditions of water saturation in the habitat.

Due to fluctuations in the biotic and abiotic factors of the environment, seasonal changes in population density of macrofauna are known to occur from season to season and from year to year. Interestingly, the maximum counts of *Uca lactea* in the present study were obtained during summer probably related with higher temperatures and salinity. *Uca lactea* counts were also higher from October to December due to an undisturbed substratum. *Scylla serrata*, one of the important commercial species, has the maximum count in the summer. The species is known to prefer low salinity, hence further studies are needed to understand its abundance during the periods of high salinity in summer months. It was found to occur in burrows during the daytime. The depth of the burrows varied from 1.0 to 1.5 m from the surface and the

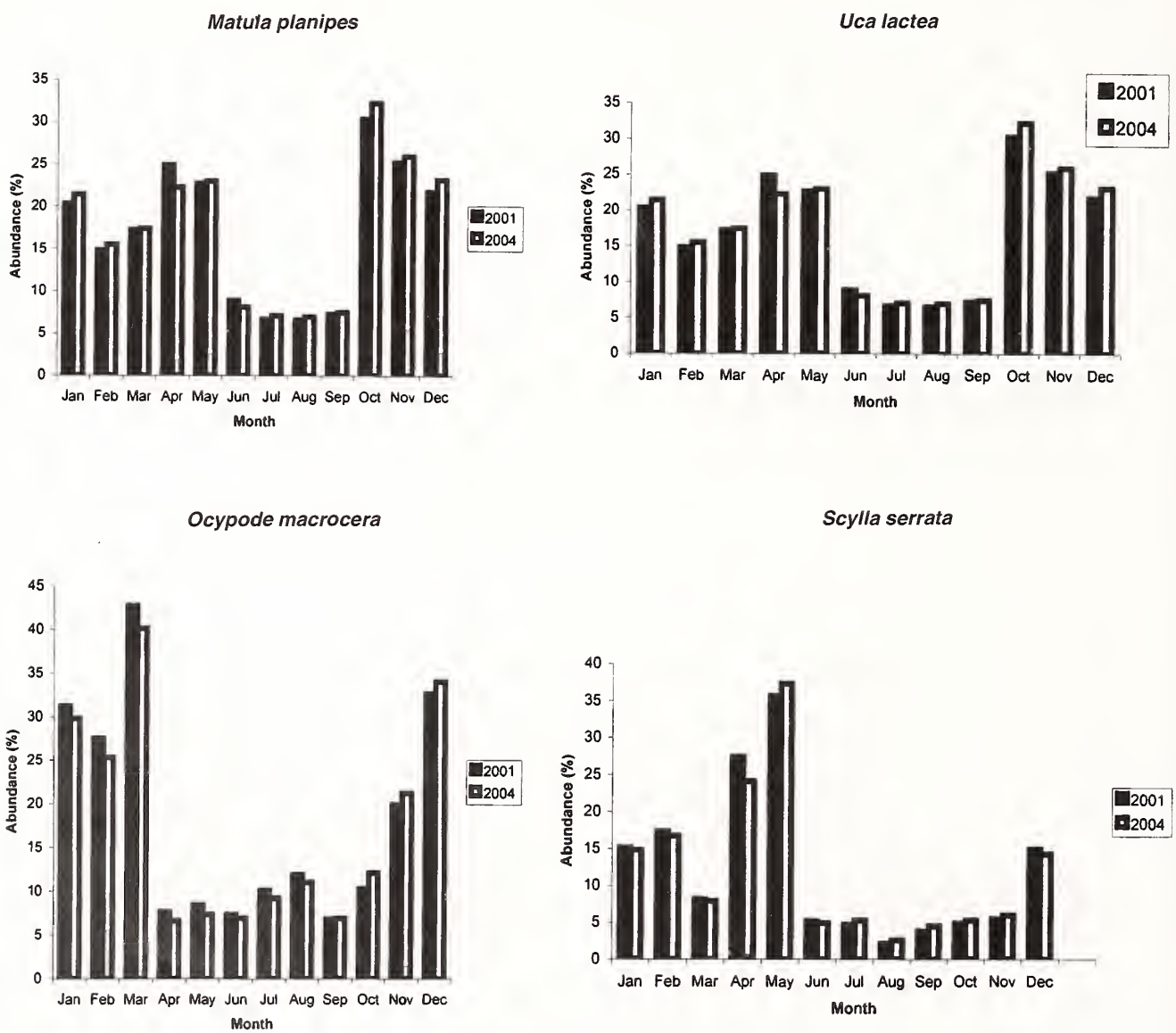

Fig. 3: Comparative chart showing monthly abundance of four crab species recorded from the study area during 2001 and 2004

diameter at the mouth from 8 to 16 cm. During low tide the burrows are flooded with sea water. Dev Roy and Das (2000) reported that the species also inhabits the muddy banks of creeks, channels and mangroves. Another crab species, *Varuna litterata*, had the maximum count during monsoon. The Red Crab *Ocypode macrocera* is found throughout the year with the peak in December-March, and the Two-spined Crab *Matuta planipes* is found in the postmonsoon period. The crab *Charybdis rostrata* occurs in this area throughout the year and dominates all the other species in number, with the peak in the late monsoon period.

As stated twenty-four species of prawns and two species of lobsters were recorded from the Digha coast. These species occur in abundance from June to August, with the peak in July. For meeting the increasing demand of prawn seeds for prawn culture farms, the coastal population is greatly involved in wild harvesting of prawn seeds, in particular seeds of *Penaeus monodon*. From November to February, netting of prawn seeds is done intensively. This wild harvest undoubtedly destroys seeds of other species of prawn and various finfishes.

The results of the present study agree with the findings of Brady (1943), who showed that the distribution of fauna varied with seasons, occurring in different tidal levels during different seasons. The seasonal dynamics exhibited by the *Donax-Odostomia* populations on Digha Beach apparently follow a similar pattern.

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DISTRIBUTION AND STATUS OF THE ASIATIC BLACK BEAR *URSUS THIBETANUS* IN INDIA[1]

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In 1994-1995, the first author evaluated the status and distribution of the Asiatic Black Bear in India and reported presence of the species in 53 protected areas and 62 other localities. After 10 years, we assessed the status and distribution of the Asiatic Black Bear through a questionnaire survey (n=90), results of recent field surveys, and expert knowledge. The results of our 2005 survey (83% returned responses) indicate that the Asiatic Black Bear is found in 82 protected areas and 98 other localities. Using rule-based modelling in a GIS, we estimated the potential Asiatic Black Bear habitat range in India to be *c.* 270,000 sq. km and used densities of 1 bear /40 sq. km and 1 bear /50 sq. km to extrapolate an estimated Asiatic Black Bear population of 5,400 to 6,750. After the 2005 survey, substantial information has been added to the existing knowledge on the distribution and status of the Asiatic Black Bear in India. This includes confirmation of its presence in 21 protected areas and 45 other localities for the first time. Poaching for illegal trade in bear parts, retaliatory killings to reduce bear-human conflicts and habitat loss are the major threats to the species in India. Asiatic Black Bear populations in India seem to be declining in many areas, although no quantitative information on the population trend is available due to the lack of a regular monitoring exercise. We recommend that control of poaching for the illegal trade in bear parts and retaliatory killings, and prevention of habitat degradation or loss, and monitoring of bear populations be accorded top priority.

Key words: distribution, status, protected area, threats, conservation, management

INTRODUCTION

The Asiatic Black Bear has been reported to be continuously distributed from southern and eastern Asia westward through Pakistan and Afghanistan to Baluchistan Province of Iran, and eastward to Indo-China through much of China, Korea and Japan with an isolated population in Taiwan (Cowan 1970; Servheen 1990; Mallon 1991; Sathyakumar 2001). Schaller (1977) reported a wide distribution for the Asiatic Black Bear from Russia and Korea to Indo-China and from the forests of the Himalaya below 3,750 m west, as far as Afghanistan and Iran. The Himalayan region and the hills of north-east India cover *c.* 591,800 sq. km (18% of India) and probably hold one of the largest populations of the Asiatic Black Bear in Asia. Johnsingh (2003) has presented an excellent review on the status of all four species of bear in India along with recommendations for their conservation and management. He reported that the Asiatic Black Bear is present in at least 56 protected areas and estimated its habitat range in India to be about 300,000 sq. km and its population to be a minimum of 3,000 animals.

In this paper, we review the distribution and relative abundance of the Asiatic Black Bear in India based on a review of the existing literature, results of recent field surveys, a questionnaire survey, expert knowledge, and a few interviews with scientists, researchers, forest and wildlife managers, and field staff of the Forest Departments in northern and north-eastern India. We compare the results of this survey with the results of a similar survey carried out in 1994-1995 (Sathyakumar 2001) and make an assessment of the changes in the information on the distribution of the Asiatic Black Bear in India during the period from 1995 to 2005. We also make a realistic estimate of the potential Asiatic Black Bear distribution range and its population in India.

MATERIAL AND METHODS

In 2005, a questionnaire was developed that requested the following details: bear sightings or signs (faeces, feeding/resting signs, tracks) in PAs such as national parks, wildlife sanctuaries, conservation reserves and adjacent areas (forest divisions, reserved forests); relative abundance of bears (very rare, rare, fairly common, common or abundant) based on the frequency of encounters and their signs in the area; information on the past and present relative abundance; the extent and magnitude of threats to the Asiatic Black Bear and its habitats; bear-human conflicts; conservation and management, and the season(s) or month(s) and duration of time spent by the respondent in the Asiatic Black Bear habitat. The questionnaire was sent to protected area (PA) managers (n=90) who were then working, or who had worked for at least 2 years in the Asiatic Black Bear range states of India, namely Jammu and Kashmir, Himachal Pradesh, Uttarakhand, West Bengal, Sikkim, Arunachal Pradesh, Meghalaya,

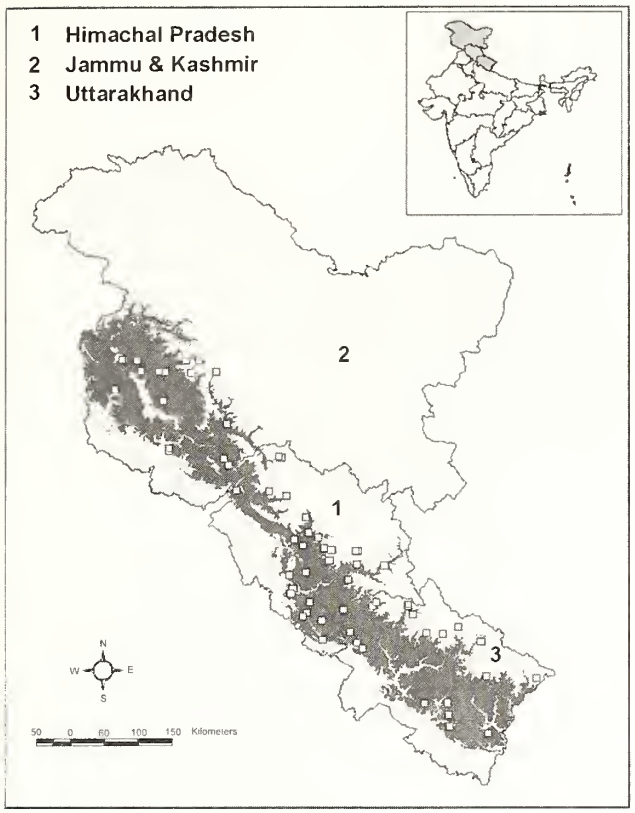

Fig. 1: Asiatic Black Bear distribution in northern India (states of Jammu and Kashmir, Himachal Pradesh and Uttarakhand); Squares denote protected areas

Manipur, Mizoram, Nagaland and Tripura; 83% of the questionnaire were returned. Informal interviews were held with a few scientists and PA managers to validate and enhance the available information. The information on the relative abundance of the species in PAs was updated whenever additional knowledge became available. The second author has carried out extensive wildlife surveys in north-east India since the early 1980s, and the information on the status and distribution of Asiatic Black Bear was refined for north-east India based on results of such recent surveys. An approximate distribution range map for the Asiatic Black Bear in India was prepared based on rule-based modelling (altitude range limits and forest cover) using a GIS and refined from expert knowledge and questionnaire responses. The rule-based model works on the basis of Boolean logic, which relies on well established available knowledge and determines the area to be either suitable (1) or unsuitable (0). The altitude range (1,200 to 3,300 m in the Western Himalaya, 70 to 4,300 m in north-east India) that is potentially used by the Asiatic Black Bear during summer was used in the model. Availability of forest cover was the other parameter that was used in the model. Asiatic Black Bear are also known to use relatively productive habitats that are man-made, such as croplands and orchards that are interspersed with or that lie adjacent to forested habitats (Sathyakumar 2001; Johnsingh 2003). Arc/Info was used to develop the distribution map.

RESULTS

Asiatic Black Bear: Distribution and Relative Abundance

In India, the Asiatic Black Bear inhabits forested habitats ranging in altitude from 1,200 m to 3,300 m (Prater 1980), and also in areas below 1,200 m in the Siwaliks. Its range overlaps with that of the Sloth Bear (*Melursus ursinus*) below 1,200 m and that of the Himalayan Brown Bear (*Ursus arctos isabellinus*) above 3,000 m. In north-east India, the range overlaps with both the Sloth Bear and the Sun Bear (*Ursus malayansis*) (Choudhury 1997a, b). The Asiatic Black Bear is distributed throughout the Himalayan ranges (Fig. 1) in the north-west (Jammu and Kashmir; Himachal Pradesh), west (Himachal Pradesh and Uttarakhand), middle (Sikkim and northern West Bengal) and east (Arunachal Pradesh). The species is also present in the hills at the edge of the plains of other north-eastern states of India (Fig. 2). The Asiatic Black Bear distribution in the Indian subcontinent is contiguous with those in Nepal (eastward from Uttarakhand to Sikkim) and Bhutan (eastward from Sikkim to Arunachal Pradesh). At present, the Asiatic Black Bear is continuously distributed in North India, all along the Himalaya (1,200 to 3,300 m) and the Eastern Himalayan ranges, and the hills of north-east India (70 to 4,300 m). The results of the 2005 survey indicated that the Asiatic Black Bear occurs in 82 PAs (Table 1) and over

Table 1: Asiatic Black Bear distribution in protected areas (PAs), forest divisions (FDs) and reserved forests (RFs) in India, 2005

State	PAs	FDs & RFs	Elevation (m)	Status
Jammu and Kashmir	16	>20	1,000-3,300	Fairly common
Himachal Pradesh	21	>25	1,000-3,300	Fairly common
Uttarakhand	10	>15	1,000-3,300	Fairly common
West Bengal (northern)	4	>1	200-3,000	Rare
Sikkim	3	>2	300 up	Rare
Arunachal Pradesh	9	>10	100 up	Common
Assam	7	>15	70-1,900	Rare
Meghalaya	3	>4	80-1,500	Very rare
Mizoram	6	>2	100-2,100	Very rare
Tripura	1	>1	200-1,000	Occasional
Manipur	1	>2	150-2,900	Rare
Nagaland	1	>1	120 – 3,800	Fairly common
Total	82	>98		

98 forest divisions (FDs), reserved forests (RFs), and forested valleys (FVs). PAs include national parks (NP), wildlife sanctuaries (WS), conservation reserves (CR) and community reserves (CMR).

Jammu and Kashmir: The Asiatic Black Bear is reported from 16 PAs and 20 FDs, RFs, and FVs. Survey respondents reported the status of the Asiatic Black Bear as 'fairly common'. The best known populations of the Asiatic Black Bear in India are in this state (Table 2a). The bear is also reported from over 20 other areas and some of these include FDs in Lidder (Pahalgam), Naranaga, Sindh, Wangat and Anantnag, and the RFs (RF) of Gugnar, Bianoi, Pir Panjal, Zaberwan, Bandipora and Kahai (M.S. Bacha, Department of Wildlife Protection, Jammu and Kashmir, pers. comm. in 2005). The Asiatic Black Bear is reported from Banihal CR, Sumchan Saphare WS and proposed PAs, such as Pir Panjal NP, Ghambiar Mongtu WS, Dhera-ki-Gali WS, Ans River WS, and Nowshera WS. In Jammu region, it is reported from the FDs of Marwa, Rambandh, Batote, Doda, Badhruwa, Kistwar, Poonch, Rajouri, Nowshera, Reasa, Mahor, Udhampur, Jammu, Ramnagar and Bilwar (N.A. Kitchloo, Department of Wildlife Protection, Jammu and Kashmir (pers. comm. in 2005).

The responses of the 2005 survey have added substantial information on the distribution of Asiatic Black Bear in this state. The presence of the Asiatic Black Bear has been reported from PAs that have no reported presence of Asiatic Black Bear in the past and from five newly created CRs. Survey respondents reported that Asiatic Black Bear feeding signs and scats were commonly encountered in these areas and that these were of bear-human conflicts. Saberwal (1989) reported Asiatic Black Bear density of 1.3-1.8 bears/sq. km in the Lower Dachigam area of Dachigam NP during high fruit abundance of 1988-1989. Bear encounter rates along transects for the same period ranged from 0 to 3.5 bears/km and 25 to 40 bears were estimated to use Lower Dachigam from late June through October (particularly in early September).

Himachal Pradesh: The Asiatic Black Bear is present in and around 21 PAs (Sathyakumar 2001). Outside PAs, Asiatic Black Bear is reported to occur in an additional 25 areas, including the forested areas of Pangi (Chenab Catchment) and Bharmaur valleys (Ravi catchment) in Chamba district; Dhaula Dhar Range (Beas Catchment), Bara Bangal, Chota Bangal and Bir in Kangra district; Parbati Valley, Pandrabis, Bashleo Pass (Sutlej Catchment), Solang and Jagatsukh valleys in Kullu district; the upper catchments of Bata and Giri in Solan and Shimla districts; the catchments of the Sutlej and Yamuna, Shimla ridge, Karsog, Shali, Kandyali, Hatu and Moral Kanda areas in Shimla district; and the Ropa valley, and Kalpa and Kaksthal areas in Kinnaur

Table 2a: Asiatic Black Bear populations and their past and present relative abundance in Protected Areas (Jammu & Kashmir, Himachal Pradesh) based on questionnaire responses, recent surveys and interviews (modified from Sathyakumar 2001)

State, Protected Area (area in sq. km)	Relative abundance	
	1990s	2005
Jammu and Kashmir		
Ajas CR (48)	Fairly common (?)	Fairly common
Bran-Harwan CR (19)	Fairly common (?)	Fairly common
City Forest (Sálim Ali) NP (10)	Fairly common (?)	Fairly common
Dachigam NP (171)	Very common (?)	Common
Gulmarg WS (139)	Fairly common (?)	Fairly common
Hirapora WS (115)	Fairly common (?)	Rare
Khiram-Shikargarh-Panyar-Khangund CR (118)	Fairly common (?)	Fairly common
Khrew-Khonmoh CR (117)	Fairly common (?)	Fairly common
Kistwar NP (400)	Unknown (1995)	Fairly common
Lachipora WS (96)	Fairly common (?)	Fairly common
Limber WS (44)	Fairly common (?)	Fairly common
Naganari CR (22)	Fairly common (?)	Fairly common
Overa-Aru WS (511)	Fairly common (?) (1991)	Fairly common
Rajparian (Daksum) WS (49)	Common (?)	Fairly common
Thajwas (Baltal) WS (211)	Fairly common (?)	Rare
Wangat CR (59)	Fairly common (?)	Common
Himachal Pradesh		
Bandli WS (41)	Unknown (1995)	Rare
Chail WS (109)	Unknown (1995)	Fairly common
Churdar WS (66)	Unknown (1995)	Unknown
Daranghati WS (167)	Fairly common (1994)	Unknown
Gamgul Siahbehi WS (109)	Unknown (1994)	Fairly common
Great Himalayan NP (755)	Fairly common (1994)	Fairly common
Kias WS (14)	Fairly common (1994)	Fairly common
Kalatop-Khajjiar WS (69)	Fairly common (1994)	Fairly common
Kanawar WS (61)	Fairly common (1994)	Common
Khokhan WS (14)	Unknown (1995)	Common
Kugti WS (379)	Fairly common (1993)	Fairly common
Lippa Asrang WS (349)	Common (1993)	Unknown
Majhatal WS (58)	Unknown (1995)	Fairly common
Manali WS (32)	Rare (1991)	Rare
Nargu WS (278)	Unknown (1995)	Fairly common
Rupi Bhaba WS (738)	Common (1994)	Fairly common
Sangla (R/Chitkul) WS (650)	Very common (1994)	Unknown
Sechu Tuan Nala WS (103)	Unknown (1995)	Unknown
Shikari Devi WS (72)	Rare (1994)	Fairly common
Talra WS (40)	Unknown (1995)	Unknown
Tundah WS (64)	Very common (1993)	Unknown

WS - wildlife sanctuary; NP - national park; CR - conservation reserve; ? - year unknown

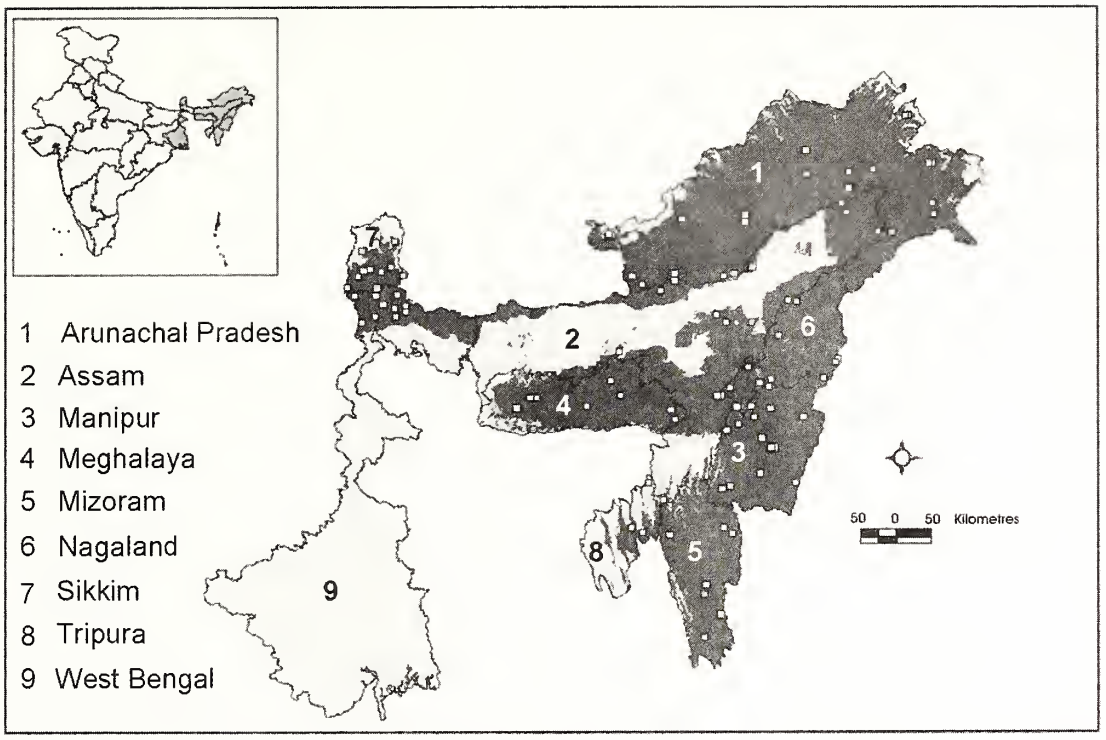

Fig. 2: Asiatic Black Bear Distribution in north-eastern India (states of West Bengal, Sikkim, Arunachal Pradesh, Assam, Meghalaya, Mizoram, Manipur, Nagaland and Tripura); Squares denote protected areas

district (Sathyakumar 2001).

Vinod and Sathyakumar (1999) reported that Asiatic Black Bear encounter rates along transects ranged from 0.01 to 0.02 bears/km in the Great Himalayan NP between 1996 and 1999. Survey respondents reported bear-human conflicts to be high around the PAs. Chauhan (2003) on the basis of an assessment of wildlife-human conflicts at the Great Himalayan NP during the period 1989-1998 has reported that 26% of livestock depredation was by Black and Brown bears and this occurred primarily in alpine rangelands (58%) where livestock grazing is generally unsupervised, with depredation occurring largely during September (41%).

Uttarakhand: The Asiatic Black Bear is present in and around 10 PAs (Table 2b): Bears are reported in 15 areas outside PAs, including the FDs of Tons, Uttarkashi, Tehri, Badrinath, Pithoragarh, Narendra Nagar, Chakrata, Ram Nagar, Almora, Bageshwar, Nainital, and Kedarnath Wildlife Division. Bears have also been reported in the Yamunotri and Gangotri valleys, the upper catchment of the Ram Ganga, Ladhiya Valley and some parts of the Terai FD (Sathyakumar 2001).

Recent surveys have revealed that the status of the Asiatic Black Bear has improved during a 10 year period in Nanda Devi NP from no sightings or evidence in 1993 to one sighting and four scats in 2003 (Sathyakumar 2004). Asiatic Black Bear encounter rates along transects in this NP ranged from 0 to 0.66 scats/km during 2003. In the Valley of Flowers NP and the buffer zones of Nanda Devi BR, 28 individuals (including five females with cubs), were sighted during a one month survey period (November-December 2005) and encounter rates along transects ranged from 0 to 0.4 bear scats/km (G. Pandey, Nanda Devi BR, Uttarakhand, India, pers. comm. in 2006). In Rajaji NP, the Asiatic Black Bear range overlapped with that of the Sloth Bear; the Asiatic Black Bear was reported to be 'rare' (Table 2b). In Rajaji NP, Asiatic Black Bear were photographed at remote camera traps on 10 occasions out of 900 trap nights (B. Pandav, Wildlife Institute of India, Dehradun, India, pers. comm. in 2006).

West Bengal: Survey respondents reported that Asiatic Black Bear occur in and around four PAs in the northern part of West Bengal (Table 2b) and in the forested areas of Darjeeling, Kalimpong Hills, Kolbang, Rehit and Pankasari RFs (V.K. Sood and Tapan Das, State Forest Department, pers. comm. in 2005). The status of the Asiatic Black Bear in Senchal WS is unknown, but it has been reported to occur in this PA.

Sikkim: The Asiatic Black Bear is reported to be 'fairly common' in Kanchendzonga NP (Gut Lepcha, Department of Forests, Environment and Wildlife Management, Government of Sikkim, pers. comm. in 2005). Sathyakumar (2001) has reported that bears occur in suitable undisturbed forested areas at elevations between 1,200 and 3,000 m in Sikkim (Table 2b).

Table 2b: Asiatic Black Bear populations and their past and present relative abundance in protected areas (PAs: Uttarakhand, West Bengal, Sikkim, Arunachal Pradesh, Assam) based on questionnaire responses, recent surveys and interviews (modified from Sathyakumar 2001).

State, Protected Area (area in sq. km)	Relative abundance	
	1990s	2005
Uttarakhand		
Askot WS (600)	Rare (1994)	Fairly common
Corbett NP (521) & TR	Rare (1993)	Rare
Govind NP & WS (953)	Rare (1992)	Common
Kedarnath WS (975)	Fairly common (1994)	Common
Mussorie WS (11)	Very common (?)	Common
Nanda Devi NP (625)	Rare (1993)	Fairly common
Nanda Devi BR (5,150)	Fairly common (1993)	Fairly common
Rajaji NP (820)	Unknown	Rare
Valley of Flowers NP (88)	Fairly common (1995)	Fairly common
West Bengal		
Buxa TR (759)	Rare (1999)	Rare
Mahananda WS (158)	Unknown (1995)	Rare
Neora NP (88)	Common (1999)	Fairly common
Singalila NP (79)	Rare (1999)	Fairly common
Sikkim		
Fambong Lho WS (52)	Unknown (1995)	Rare
Kanchendzonga NP (1,784)	Common (1999)	Fairly common
Pangolakha NP (128)	Common (1999)	Rare
Arunachal Pradesh		
Dibang WS (4,149)	Common (1999)	Fairly common
Eagle's Nest WS (217)	Common (1999)	Fairly common
Itanagar WS (140)	Fairly common (1995)	Fairly common
Kamlang WS (783)	Fairly common (1994)	Fairly common
Kane WS (55)	Rare (1991)	Rare
Mehao WS (282)	Common (1999)	Fairly common
Mouling NP (483)	Common (1999)	Fairly common
Namdapha NP and TR (4,985)	Rare (1996)	Fairly common
Pakke WS (862)	Common (1999)	Fairly common
Sessa Orchid Sanctuary (100)	Common (1999)	Fairly common
Taley Valley WS (425)	Unknown (1994)	Fairly common
Assam		
Barail WS (326)	Fairly common (1996)	Fairly common
East Karbi Anglong WS (222)	Fairly common (1996)	Fairly common
Marat Longri WS (451)	Rare (1992)	Very rare
Manas NP (500)	Rare (1995)	Very rare
Nameri NP (200)	Rare (1998)	Very rare
North Karbi Anglong WS (96)	Rare (1999)	Rare
Sonai-Rupai WS (220)	Rare (1998)	Very Rare

WS - wildlife sanctuary; NP - national park; TR - tiger reserve; BR - biosphere reserve; ? - year unknown

Assam: The Asiatic Black Bear occurs throughout the hills of Assam and has been reported to occur in the plains (Choudhury 1997a). Assam is not indicated in the 1994-1995 survey (Sathyakumar 2001) as it was believed that this state did not hold any Asiatic Black Bears, although a few individuals were thought to inhabit areas along the border with Arunachal Pradesh. During the 2005 survey, we obtained information on the presence of the Asiatic Black Bear in seven PAs (Table 2). The Asiatic Black Bear is also fairly common in the forested areas of Karbi Anglong district (Choudhury 1992) and North Cachar Hills district (Table 2b).

Arunachal Pradesh: With more than 80% of its geographical area under forest cover, Arunachal Pradesh has a nearly continuous distribution of the Asiatic Black Bear, but there are serious threats from poaching. It is reported to be 'fairly common', occurring in suitable undisturbed habitats throughout Arunachal Pradesh (Sathyakumar 2001). It is reported to occur in 11 PAs in this state (Choudhury 2003) (Table 2b). The Asiatic Black Bear has also been reported to occur in other areas, such as Hot Spring, Ditchu (Lohit district), Taley Valley RF, Anini Social FD and Siang district. A survey of wild animal use by humans revealed that in two villages of Lower Dibang Valley district, at least 52 bears were killed in a single year (Choudhury and Rengma *unpubl.*).

Mizoram and Meghalaya: The Asiatic Black Bear distribution extends into Mizoram and Meghalaya where it is reported to occur in five and three PAs respectively. However, survey respondents reported the species as 'rare' in these areas (N.R. Pradhan, State Forest Department, pers. comm. in 2005). In Meghalaya, the Asiatic Black Bear is present in and around Balphakram NP, Nokrek BR and Nongkhyllem WS (Sathyakumar 2001). It is reported as 'rare' in the Garo, Khasi, and Jaintia hills, Saipung RF and Narpuh RF (S. Kumar, State Forest Department, pers. comm. in 2005) (Table 2c).

Tripura, Manipur and Nagaland: The hill ranges in Tripura contain small scattered populations. The Asiatic Black Bear is reported in Trishna WS (S. Dasgupta, Wildlife Institute of India, pers. comm. in 2004) Kailashahar FD, Manu, Kanchanpur FD, Longthorai RF, and Deo RF, although the status is unknown. Manipur, Mizoram, Nagaland and Arunachal Pradesh are the only four states in India where the distribution ranges of the Asiatic Black Bear and Sun Bear overlap. In Manipur, the Asiatic Black Bear is found throughout the hilly areas (Gee 1967; Choudhury 1992). Bears are reported to occur in Kailam WS (Table 2c) and Kangpokpi-Tamenglong Protected Forest (Thambou Kamei, State Forest Department, pers. comm. in 2005). In Nagaland, the Asiatic Black Bear is reported as 'fairly common' in Fakim WS (Ramesh Aima, State Forest Department, pers. comm. in

2005), but is well distributed across the state. A survey of patterns of animal use by humans revealed that large numbers of Asiatic Black Bears are killed every year. A small sample (n=15) of Phesama village had indulged in harvesting of at least 52 bears in their lifetime (Choudhury and Rengma *unpubl.*).

Habitat and population estimates

Based on the 2005 survey, we developed a distribution range map for the Asiatic Black Bear in India using a rule-based model in the GIS based on the forest cover, altitude range limits of the species and recent information on the presence/absence of this species in India (Figs 1 and 2). Based on a literature survey, the survey results and expert knowledge, we considered the altitude limits of the Asiatic Black Bear distribution range as 1,200 m and the tree line (3,300 m) in northern India and as 70 m and the tree line (4,300 m) in north-eastern India. Availability of forest cover was the other parameter that was used in the model. The Asiatic Black Bear is known to use relatively productive habitats that are man-made such as croplands and orchards that are interspersed with or that lie adjacent to forested habitats (Sathyakumar 2001; Johnsingh 2003). Using this model, we now estimate the potential Asiatic Black Bear distribution range to be 269,350 sq. km (71,445 sq. km in the Western Himalayan region and 191,445 sq. km in the Eastern Himalayan region and Northeast Hills) or about 270,000 sq. km. Density estimates for the Asiatic Black Bear in India varies between 10 bears/100 sq. km (Dachigam NP) to 6 bears/100 sq. km (some areas in Arunachal Pradesh) and 2 to 3 bears/100 sq. km (most of the distribution range). Based on these density estimates, we used densities of 1 bear /40 sq. km and 1/50 sq. km to extrapolate an estimated Asiatic Black Bear population in India of *c.* 5,400 to 6,750 animals. This estimate appears to be more realistic considering the present Asiatic Black Bear distribution and potential habitat range available in India, compared to the earlier estimate of a minimum of 3000 bears made by Johnsingh (2003).

Table 2c: Asiatic Black Bear populations and their past and present relative abundance in protected areas (PAs: Meghalaya, Mizoram, Tripura, Manipur, Nagaland) based on questionnaire responses, recent surveys and interviews (modified from Sathyakumar 2001).

State, Protected Area (area in sq. km)	Relative abundance	
	1990s	2005
Meghalaya		
Balphakram NP (220)	Unknown (1995)	Very rare
Nokrek NP and BR (80)	Unknown (1995)	Occasional
Nongkhyllem WS (29)	Rare (?)	Occasional
Mizoram		
Dampa WS (500)	Unknown (1995)	Rare
Lengteng WS (60)	Unknown (1995)	Rare
Murlen NP (100)	Unknown (1995)	Rare
Ngengpui WS (110)	Common (1999)	Rare
Phawngpui NP (50)	Common (1999)	Rare
Tripura		
Trishna WS (195)	Unknown (1995)	???
Manipur		
Kailam WS (188)	Unknown (1995)	Very rare
Nagaland		
Fakim WS (6)	Unknown (1995)	Fairly common

WS - wildlife sanctuary; NP - national park; BR - biosphere reserve; ? - year unknown

DISCUSSION

Limitations of the questionnaire survey

After the 2005 survey, substantial information has been added to the existing knowledge on the distribution of the Asiatic Black Bear in India. This only indicates an increase in the awareness on the importance of reporting the presence/absence of the Asiatic Black Bear in an area, and does not mean that the distribution range of this species has increased in India. Asiatic Black Bear populations are declining in many areas due to poaching for illegal trade in bear parts and habitat loss/degradation. However, there is no quantitative information available to indicate negative changes in the population trend of the Asiatic Black Bear in India as no regular monitoring exercise is in practice. The qualitative assessment of the relative abundance of the Asiatic Black Bears in a PAs is made by the PA manager based on the bear sightings and bear sign encounters that he/she has recorded and/or based on the sightings / bear sign encounters that were recorded by the field staff. This may be inconsistent due to varying levels of effort made and observer efficiency, and therefore may not be a reliable indication of the actual status.

Prior to the 1994-1995 survey, there was no information on the relative abundance of the Asiatic Black Bear in PAs (Sathyakumar 2001). After the 2005 survey, an assessment of the changes in the relative abundance of bears in PAs between the 1995 and 2005 surveys was made. It appears that there has been a marginal improvement in the status (qualitative relative abundance) of the Asiatic Black Bear in 24 PAs, no change in status in 30 PAs and a declining status in 28 PAs. However, as mentioned above, such an interpretation would be incorrect due to the inconsistency in the reporting due to varying levels of effort made to record bear sightings and/or bear signs by observers with varying

efficiency levels. It would be ideal to have regular bear sign surveys along transects/trails in different parts of a PA during different seasons so that we can obtain estimates of bear encounter rates along with the variance. Such estimates would be of great help in monitoring changes in the Asiatic Black Bear status or population in an area.

Human-Bear Interactions

Conflicts with humans: One of the most serious limiting factors for Asiatic Black Bear conservation in India is the response of people to human-Asiatic Black Bear conflict. Reports to the Forest and Wildlife Department of Asiatic Black Bears killing livestock and attacking humans are common, largely in the north-western and western Himalayan region. For example, in Uttarakhand, Asiatic Black Bears accounted for 28.5% of 540 attacks on humans by large carnivores between 1991 and 2001. Of these attacks, 9% resulted in human fatalities (Chauhan *unpubl.*). In the Great Himalayan NP, 350 of 1,348 (26%) incidents of livestock predation during 1989-1998 involved Black or Brown bears (Chauhan 2003). In Arunachal Pradesh, Asiatic Black Bears cause damage to maize, which is a major crop for many hill tribe people. Possible causes for the increased incidences in the reporting of livestock depredation and attacks on humans by Asiatic Black Bears are (1) shrinking habitat due to extension of agricultural lands, other human encroachment, and habitat degradation, which have led to increased use of agricultural lands by bears; (2) increasing human and livestock populations in and around PAs and forested areas, and increased dependence on forests by humans leading to increased frequencies of bear-human encounters; (3) unsupervised livestock grazing; and (4) increased awareness among local people regarding compensation paid by the government for damage caused by wildlife, leading to an increase in the proportion of incidents reported. As a result of the above, any increase in Asiatic Black Bear population in an area in the recent past is very unlikely with the exception of a very few undisturbed areas (Sathyakumar 2001).

Poaching threats: Asiatic Black Bear populations in India are largely threatened due to poaching for the gall bladder and skin. Although the former is believed to be of medicinal value, the latter is used for trophy or ornamental purposes. Many Chinese medical texts recommend the Asiatic Black Bear as the source for medicinal bile. Although bears are protected in India, it is difficult to prosecute in poaching cases because of lack of *prima facie* evidence in the courts. Poaching and the illegal trade across international borders is thought to be widespread. India has long boundaries with Pakistan, China, Nepal, Bhutan and Myanmar, often in remote, rugged mountainous terrain, making it difficult to police the borders and control the cross-border trade. According to the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES), between 1975 and 1993 about 1,307 kg of bear gall bladder was sold in international markets along with 11,667 kg, 44,219 units, 750 cartons and 500 boxes of bear derivatives (Mills *et al.* 1995). For the same period, about 4,136 kg of gall bladder is also reported from the Republic of Korea, which would mean another 68,933 bears (at 60 grams of bile/bear) killed for the trade. The retail price of bear gall bladder in California in the USA is about US $1,200-2,000/gm and it is up to US $500 /gm in South Korea (Mills *et al.* 1995).

The growing demand for bear products in Asia has led to serious impacts on bear populations in India. In Arunachal Pradesh and other north-eastern states, indigenous people hunt the Asiatic Black Bear for its skin and meat. For example, the 'Nishi' (earlier known as Daffla) people wear bear skins on the back of their neck and use them in making 'dao' (knife) holders. All huts of indigenous people have a display of wild animal skulls and skins, many including parts from Asiatic Black Bears.

Habitat degradation: Based on the 2005 estimate, the potential Asiatic Black Bear distribution range in India is estimated to be about 270,000 sq. km which is almost identical to the estimate made by Johnsingh (2003). Of this total potential Asiatic Black Bear habitat range in India, less than 10% is protected under the existing network of PAs. Throughout India, there are major threats to Asiatic Black Bear habitats. Habitat degradation is largely due to development projects and human dependence on forests for fuel wood and fodder (many of them bear food plants), as well as the extraction of other forest products such as montane bamboo (*Arundinaria falcata*, *Chimnobambusa jaunsarensis*, *Thamnocalamus falconeri*, *T. spathiflorus*). In Arunachal Pradesh and Sikkim, habitat loss is mainly due to development activities. In the north-eastern states, *jhum* (shifting cultivation) has led to serious impacts on Asiatic Black Bear habitat. In Meghalaya, about 95% of the land is privately owned and the state government has difficulties in protecting wildlife or habitats in these areas (Sathyakumar 2001). Over 70% of the PAs with Asiatic Black Bear populations have an extent of less than 500 sq. km and suffer from anthropogenic pressures from within and outside. Identifying forested areas adjacent to PAs and forest corridors between PAs is crucial.

Conservation Recommendations

The recently amended Indian Wildlife (Protection) Act of 1972 (GoI 2003) offers options for creation of new categories of PAs such as CRs and Community Reserves and CMRs. Crucial Asiatic Black Bear populations that occur outside the PA network, but form corridors to existing population units,

could be protected through creation of CRs and CMRs and by community participation. The Jammu and Kashmir Government has recently created ten CRs. Such efforts have to be taken up in other states, particularly in north-east India.

To control poaching and smuggling, additional well-trained wildlife staff are needed. Adequate facilities, incentives, remote area allowances, equipment and motivation are required for wildlife staff in all areas. Wildlife awareness programmes for the Indian Army, border police personnel and the general public are needed. The Government should regulate all development activities, such as dam and road construction in Asiatic Black Bear and other wildlife habitats by ensuring completion of environmental impact assessment studies prior to project approval. Additionally, the short cycle of *jhum* (shifting cultivation) in north-eastern states needs to be replaced with longer cycles (Sathyakumar 2001).

Status surveys should be conducted for the Asiatic Black Bear in most parts of Sikkim, northern West Bengal, Arunachal Pradesh and other north-eastern hill states. Regular monitoring of Asiatic Black Bear populations based on direct and indirect evidences should be carried out in PAs. Simple indices of relative abundance, such as encounter rates based on direct (sightings) and indirect evidence (bear tracks, scats, rubbing signs, rake marks on trees, feeding signs and other) could be obtained by sampling trails or transects in different parts of a PA or RF regularly in different seasons. Scientific research on the ecology of Asiatic Black Bear is necessary because information on food and feeding habits, habitat utilisation, bear-human conflicts and ranging patterns is crucial for reducing conflicts and for the long-term conservation and management of this species in India. An assessment of the illegal trade in bear parts is also extremely important to understand the extent and magnitude of impacts on the wild bear populations in India.

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STUDIES ON THE OCCURENCE, AVAILABILITY AND MARKETING OF CRAB (*SCYLLA* SPP.) BY CRAB MONITORING PROGRAMME OF RATNAGIRI DISTRICT, SOUTH KONKAN COAST OF MAHARASHTRA, INDIA [1]

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A short-term (45 days) crab (*Scylla* spp.) monitoring programme was conducted in 51 villages from five coastal talukas of Ratnagiri district The survey revealed that two species, namely *Scylla serrata* and *S. tranquebarica* are found along the coast of Ratnagiri districts where the former is abundant. The indigenous techniques of crab farming and various crab harvesting methods were studied in the survey. The survey also conveyed the message of conservation of crabs along the coastal villages of Ratnagiri district. The details are discussed in the paper.

Key words: crab monitoring, *Scylla tranquebarica*, *Scylla serrata*, marketing

INTRODUCTION

Crab fishery in India is yet to be recognised as a major fishery despite the abundant occurrence of edible crabs all along the Indian coast. There are about 600 crab species occurring in Indian waters; only a few of them are used for human consumption. The most important among these are *Scylla serrata*, *S. tranquebarica*, *Protunus pelagicus*, *P. sanguinolentus*, *Charybdis crusiata* and *C. feriata* (pers. comm.). Among these, the *Scylla* spp., commonly referred to as the Mud or Green Crab form the mainstay of the crab fishery of India and are economically important

Crabs belonging to the genus *Scylla* inhabit brackish waters, such as mangrove areas and estuaries, throughout the Pacific and Indian oceans from Hawaii, South Japan, Taiwan, Philippines and Australia to the Red sea and South Africa (Chhapgar 1957; Motoh 1979; Aiyun and Sillang 1991). In India, crabs are found abundantly on the east and west coasts in Kerala, Tamil Nadu, West Bengal and Orissa. In Maharashtra, two species of genus *Scylla* have been recorded, namely *S. serrata* and *S. tranquebarica*, along the Konkan coast. The former is a well known species along the Konkan coast, but the latter has been recorded only recently by the faculty of Konkan Agricultural University in the north Konkan coast of Maharashtra (Vartak *et al.* 2002; Singh *et al.* 2005). However, information about its occurrence in the Konkan coastal region is far from complete. Detailed information is essential as this species is important from the aquaculture point of view. Hence, a short-term crab monitoring programme was conducted along Ratnagiri district with the aim of collecting information on the occurrence of *S. tranquebarica* along the coast. This study also aimed to collect information about the places where the seed of this crab (*Scylla* spp.) is available; this may be beneficial for farmers in carrying out culturing and fattening activities.

MATERIAL AND METHODS

This study was undertaken in a cluster of 51 villages spread over five coastal talukas of Ratnagiri district, namely Ratnagiri, Rajapur, Dapoli, Mandangad and Guhagar (Fig. 1). Crab collectors were personally interviewed for obtaining information on the occurrence of the *Scylla* spp., its seed availability and its marketing. In addition, information was collected on existing crab culturing and fattening practices if any. All the information was collected and entered in the proforma of Appendix 1.

RESULTS

Resources

The crab monitoring survey revealed that both *Scylla serrata* and *Scylla tranquebarica* occur along the South Konkan coastal region of Ratnagiri district. *S. serrata* occurs plentifully as compared to *S. tranquebarica*. *Scylla serrata* are collected throughout the year, and are abundant during the monsoon season. The ratio of availability of both the species differs with each taluka, e.g. it is 1:4.1 in Mandangad and 1:8.2 in Ratnagiri. *S. serrata* and *S. tranquebarica* are locally known by different names according to the region. The region-wise local names for the two crabs are given in Table 1. This nomenclature is mainly based on the coloration of the crabs. In some areas *S. serrata* is called 'Lal Kurli', which means 'Red Crab', and *S. tranquebarica* is called 'Hirvi Kurli', which means 'Green Crab'

Methods of Crab harvesting along the Ratnagiri coast

Crabs are caught by various methods along the different regions of Ratnagiri district. As *S. serrata* is found in plenty along the coast, no special efforts are taken to catch them,

Fig. 1: Map showing different villages of Ratnagiri district surveyed under short-term crab (*Scylla* spp.) monitoring programme

Table 1: Local names of *Scylla serrata* and *Scylla tranquebarica* in different villages of Ratnagiri district

Name of the Taluka	Name of the village	Local name of species	
		Scylla serrata	*Scylla tranquebarica*
Mandangad	Shipole	Kali kirvi	Fakirin khadpi
	Bankot	Kali kirvi	Khadpi
	Velas	Khekda	Vaslya
	Kelshi	Kirvi	Khadpi
Dapoli	Ade	Kirva	Dhandya
	Anjarle	Chamori	Kirva
	Paj Pandhari	Kirvi	Khadpi
	Harne	Kirvi	Khadpi
	Burondi	Kirvi	Khadpi
	Kolthare	Chamori	Kirva
	Dabhol	Chamori	Kirva
Guhagar	Dhopave	Kurli	Khadpi
	Veldur	Kurli	Khadpi
	Guhagar	Kurli	Khadpi
	Asgoli	Kurli	Khadpi
	Palshet	Kurli	Khadpi
	Borya Bandar	Kurli	Khadpi
	Velaneshwar	Kurli	Khadpi
	Hedavi	Kurli	Khadpi
	Rohile	Kurli	Khadpi
	Padave	Kurli	Khadpi
Ratnagiri	Jambhari	Kurli	Kurli
	Jaigad	Gobadi lal	Gobadi hirvi
	Undi	Chavari	Khajan
	Varavade	Kali kurli	Hirvi kurli
	Kachare	Kurli	Khadapi
	Nevare	Kali kurli	Bhat
	Kotwade	Khadpi, Khajan	Kurli, Bhat
	Are	Khajan	Bhat
	Kalbadevi	Khajan	Bhat
	Sakhartar	Khajan (lal)	Bhat (hirvi)
	Majgaon	Kali kurli	Safed Kurli
	Shirgaon	Khajan	Bhat
	Mirya	Khajan	Bhat
	Karla	Kala kurli	Gorya Kurli
	Bhatye	Kurli	Kurli
	Kasop	Khajan	Bhat
	Wayangani	Khajan	Bhat
	Ranpar	Kurli	Kurli
	Ganeshgule	Kurli	Bhat
	Pavas	Kali Kurli	Narli
	Purngad	Kali Kurli	Hirvi kurli
Rajapur	Kasheli	Kurli	Kurli
	Vaitye	Kurli	Kurli
	Ambolgad	Kurli	Kurli
	Sakharinate	Lal kurli	Khadpi kurli
	Jaitapur	Kurli	Kurli
	Ansure	Kurli	Kurli
	Pangeri	Kurli, Kali kurli	Kurli, Hirvi kurli
	Sagave	Lal kurli	Khadpi kurli
	Katali	Lal kurli	Khadpi kurli

whereas catching *S. tranquebarica* is different and expensive. *S. serrata* is generally caught in a lift net. This net is made up of an iron ring to which a polyethylene mesh net is fastened to form a bag. The net is baited with trash fish, goat ears or small pieces of shark flesh. The bait, which is tied to a twine attached inside the net near the circular ring, attracts the crabs towards the lift net. The crabs get attracted towards the bait and start feeding on the bait; lifting the net at this moment

traps the crabs. The time of lifting the net from the fishing area is decided on the basis of experience and judgment.

Another method of catching *S. serrata* is hand picking. In this method, the fishermen, check the holes made by crabs during low tide. The presence of crabs inside the hole is confirmed by checking the soil inside the hole. If the soil is soft, there is a possibility of presence of a crab inside the hole. After confirming the presence of a crab in the hole, the fisherman widens the hole using an iron rod. After digging a little distance the fisherman checks the hole using his hand, which is covered with a cloth for protection against crab bites. If the crab is present, it is taken out of the hole with great care and skill.

Gill nets are used to catch *S. tranquebarica* from estuaries. Gill nets are laid at the bottom in which crabs get entangled. The entangled crabs are removed from the net. A crab with all appendages fetches a greater price than a crab with missing appendages, hence the portion of the net where a crab is trapped is trimmed to remove the crab safely with all its appendages.

Indigenous Technique of Crab fattening in Ratnagiri district

There has been a trade of *S. tranquebarica* for the last five years along the Konkan Coast, but soft-shelled crabs do not have much value. Therefore, crab collectors of this coast have tried to fatten the crabs using the galvanized iron cage string techniques unsuccessfully due to lack of technical knowledge. The details of these techniques are discussed below.

Crab fattening in galvanized cage:

In this method, eleven soft-shelled crabs (>500 gm) were stocked in a galvanized iron cage (5 x 4 x 4 inches). The crabs were fed with trash fish twice a day. The cage was kept in a mangrove bush adjacent to an estuary with natural water exchange. Eight of the crabs died due to cannibalism. However, the survivors were not hard. The failure of the technique was due to a lack of knowledge regarding the stocking density and feeding of the crabs. The fisherman were advised to stock one crab (>500 gm) per sq. m of cage for better results.

String fattening technique:

In this technique, a single soft crab is tied with nylon twine in such a manner that it can move and eat freely along the estuarine bottom. The other end of the twine is fixed to a mangrove tree. Such soft-shelled crabs are left freely in the estuary and harvested after they become hard. The drawback of this method is that they cannot protect such crabs from poaching and natural calamities.

Marketing:

The trade in crabs is well established in Ratnagiri district. Each taluka has its own marketing strategy for *S. tranquebarica*. It appears that the middlemen are common to all the marketing channels in the district. The crab agent of the region collects the crabs regularly in the morning from the houses of crab collectors. The fishermen living far from the main market carry the crabs at weekly intervals to a crab agent. They use nylon mesh bags for transportation of crabs to the market. They maintain the live crabs over a week in plastic baskets without feeding them at all. This basket along with the crabs is dipped in water for 10 minutes at 5 hour intervals in order to keep the crabs wet. If this is not done the crabs die. In Rajapur taluka a fisherman holds crabs in a wooden box constructed on the bank of the estuary where the water exchange depends on tidal influences. Feeding was restricted as crabs were held by tying their appendages.

The rates of hard-shelled and soft-shelled *S. tranquebarica* range from Rs. 250 to 300 per kg and Rs. 60 to 80 per kg respectively. The rates *S. serrata* weighing more than 250 gm range between Rs. 200 and 250 per dozen. Small sized *S. serrata* (*c.* 100 gm) are less expensive, and range from Rs. 50 to 60 per dozen.

After collecting the crabs, the agents send them live in bamboo baskets and polyethylene bags to either Mumbai or Goa, from where they are exported live to Singapore and Southeast Asian countries. Sometimes the crab collector is himself the wholesaler.

DISCUSSION

This short term crab monitoring programme gives substantial information on various aspects such as availability of crab *(Scylla* spp.), method of crab collection, abundance of species and indigenous knowledge. Chhapgar (1962) has carried out considerable work on the method of collection and the gear used for crab collection in Mumbai. Some of the gear mentioned by Chhapgar (1962) is used in Ratnagiri district. The survey also aimed at gathering information on the number of crab collectors interested in expanding crab culture/fattening activities. The crab collectors on the Ratnagiri district coast are poor, and the fattening activity could improve their livelihood by fetching a higher price. Large-scale activities are not possible due to poor finances, although fattening in cages made of bamboo or in cemented tanks could help them. There is a need for demonstration of such activities along the coastal region.

The marketing strategy in the district involves a middleman who earns more than the actual crab collector. A

taluka-wise market channel in the district will eliminate the middleman and give greater benefits to the fishermen. The indigenous techniques used by the fishermen deserve to be appreciated, but technical knowledge needs to be provided by local Institutes. Fishermen having the basic concept of fattening and culture could be guided technically to improve the success rate. In the present study, it was observed that a fisherman tried fattening the crabs in a cage, but was unsuccessful due to improper stocking of the crabs. He was guided technically and succeeded subsequently using a cage designed by himself. There is also a need for the creation of a database on the actual number of fishermen involved in the business. The database should have their addresses with contact numbers, so that any information related to crab culture can be easily transferred to them or vice versa. This will also build a strong interaction between the farmer and the Institute. In the present study, this was done and a link was established between fishermen and the Institute.

Crab resources are abundant along the coast of Ratnagiri district. But fishermen are also harvesting under-sized crabs and berried crabs. There is an urgent need to stop this practice by creating awareness among the fishermen. The concept of conserving under-sized crab should be explained to them. During the present study fishermen were guided to conserve crab resources by stopping the harvest of undersized or berried crabs.

Such surveys will surely help in conservation as well in bringing about sustainable socio-economic development of the fishermen in the region.

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Appendix 1

Proforma for Crab monitoring

A) Name of taluka: B) Name of village:

i) Crab availability: Yes/No
If yes, which species
1) *S. serrata:*
2) *S. tranquebarica*:
3) Both:
4) Any other:
If both are present what is the ratio:

ii) Type of fishing operation: Boat or Manual operation or any other method used

iii) Any crab culture operation in the area: Yes/ No
If yes, name of the farmer:
Type of culture operation: traditional/semi-intensive/ intensive:
Monoculture/Poly culture:

iv) Approximate quantity of crabs caught per day:

v) Awareness of species differences among farmers: Yes/No
If yes, what is the differentiating character?

vi) Whether farmers interested in crab culture: Yes/ No
If yes, name of the farmer:

Observations (if any):

ASPECTS OF NESTING BIOLOGY OF *CROCODYLUS POROSUS* AT BHITARKANIKA, ORISSA, EASTERN INDIA[1]

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The nesting biology of Saltwater Crocodiles *Crocodylus porosus* was studied at the Bhitarkanika mangroves, in Orissa, for two consecutive seasons between March 2005 and September 2006. A total of 54 mound nests were surveyed and monitored during this period. In Bhitarkanika *C. porosus* nest between April and August, during the wet season. The mean dimensions of all the successful nests were: height 55.4 ±5.4 cm, longest axis of base 182 ±12.2 cm. Preferred nest materials included *Achrostichum aureum* and *Phoenix paludosa* along with mud. Of the total number of 54 nests located and monitored, 72.2% had wallows. The number of body pits increased with increasing distance from water ($p < 0.05$). Of the complete clutches examined, the mean clutch size was 43.2 ±22.1 and the mean egg dimensions were: egg length 71.95 ±5.5 mm; egg width 49.3 ±3.9 mm; egg weight 121.5 ±14.0 gm. Six false nests were found among the total of 54 nests (2006), and all were located at distances of < 50 m from the successful nests. Predation was higher for the nests that were built closer to the water source than those built more inland ($p = 0.001$). Predation was relatively higher in the *Achrostichum* patches than in the *Phoenix* patches ($p = 0.001$). The egg collection followed by the Forest Department is discussed and a new strategy is recommended.

Key words: Saltwater Crocodile, *Crocodylus porosus*, nest biology, wallows, Bhitarkanika mangroves

INTRODUCTION

Saltwater Crocodile *Crocodylus porosus* has been recorded from India, Indonesia, Indo-China, Malaysia, Philippines, Papua New Guinea and Australia (Neill 1971; Braizitis 1973). In India, it is distributed sparsely in the Sunderbans (West Bengal), Bhitarkanika (Orissa) and Andaman and Nicobar Islands. Of these areas, Bhitarkanika has the highest density of Saltwater Crocodiles, with more than 1,500 individuals, of which over 10% are breeding individuals (Gopi 2007). Considering the potential vulnerability of the crocodilian species in India, the Government of India enforced protective legislation through the Indian Wildlife (Protection) Act, 1972 to conserve crocodiles and to develop crocodile farming in India. A captive breeding programme for all three species of crocodilians found in India (Mugger Crocodile *Crocodylus palustris*, *C. porosus*, and the Gharial *Gavialis gangeticus*) resulted in the recovery of these species in the wild. The restocking strategy of Saltwater Crocodiles has thus resulted in the successful release of more than 1,500 crocodiles (Kar and Bustard 1989; 1991).

Crocodylus porosus is the only crocodilian that deposits its eggs in a mound nest constructed of vegetation with varying proportions of mud or soil (Kopstein 1929; Deraniyagala 1939; Webb *et al.* 1977; Whitaker and Whitaker 1978; Lang 1980; Magnusson *et al.* 1980; Whitaker *et al.* 1980; Graham 1981). Nesting appears to be mainly during the wet seasons, and total or partial flooding of nests is common: a major cause of embryo mortality is drowning (Webb *et al.* 1977; Magnusson *et al.* 1978, 1980; Magnusson 1982). Studies have been carried out on four nests located in Sri Lanka (Deraniyagala 1939) and four nests were examined in Java (Worrell 1952). Magnusson *et al.* (1978) and Ogilby (1904) gave general descriptions of *C. porosus* nests in Australia. Worrell (1952) gave general descriptions from India and Myanmar. The nesting distribution of *C. porosus* was reviewed throughout its range by Neill (1971).

A detailed review of the available literature confirmed that there are no studies with empirical information on the nesting biology of *C. porosus* in India, though scant records of natural history information have been published as semi-scientific notes and popular articles (Pandav 1998; Gopi 2007). After research and conservation work on this species for over 30 long years, all the information that we have pertains only to the population status and conflict data. The nesting phase is a critical stage in the crocodilian life cycle and difficult to study owing to the harsh terrain and continuous presence of the mother crocodile near the nests. Because of the lack of information on Saltwater Crocodile nesting biology and behaviour, the present study aimed to investigate and collect preliminary information from the Bhitarkanika mangroves. The findings are presented and discussed within the context of

Fig. 1: The Bhitarkanika Wildlife Sanctuary, Orissa, India

the existing information relating to the Bhitarkanika mangroves.

STUDY AREA

This study was carried out in the Bhitarkanika Wildlife Sanctuary (Fig. 1), which is located between 20°30'-20°48' N; 86°45'-87°03' E in the deltaic region of the Brahmani and Baitarani rivers in Kendrapara district of Orissa. The Sanctuary encompasses an area of 675 sq. km of which 115 sq. km is under mangrove cover. The Sanctuary is bounded by the rivers Dhamara to the north, Maipura to the south, Brahmani to the west, and the Bay of Bengal in the east. The 35 km coastline from the mouth of River Maipura up to Barunei forms the eastern boundary of the Sanctuary. The annual rainfall ranges from 920 to 3,000 mm (Fig. 2). Bhitarkanika represents one of the richest and most diversified mangrove flora in the country. Fifty eight species of mangroves have so far been recorded in India, of which 55 are found in Bhitarkanika (Bannerjee and Rao 1990). The existence of one species each of *Rhizophora*, *Heritiera* and *Avicennia*, and four species of *Brnguiera* is one of the interesting features of the flora of Bhitarkanika. The dominant genera of mangroves and their associates include *Acanthus*, *Achrostichum*, *Aegialitis*, *Aglaia*, *Avicennia*, *Excoecaria*, *Brownlowia*, *Brugniera*, *Ceriops*, *Rhizophora*, *Heritiera*,

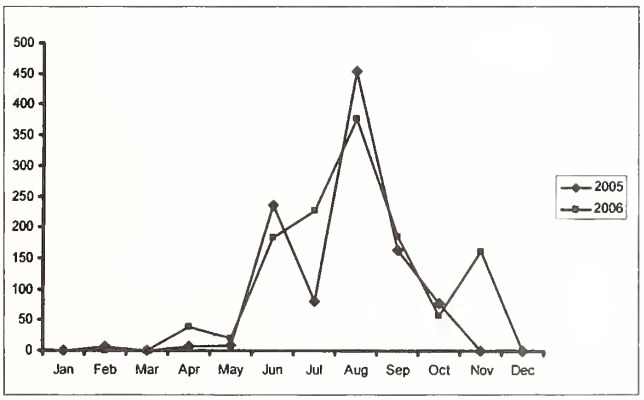

Fig. 2: Monthly rainfall pattern at Bhitarkanika National Park

Hibiscus, *Kandelia*, *Lumnizera*, *Phoenix*, *Sonneratia* and *Suaeda*.

Significant aspects of the fauna of Bhitarkanika mangroves include the presence of India's largest and oldest known heronry (Gopi *et al.* 2007) and the occurrence of the Water Monitor Lizard *Varanus salvator*, King Cobra *Ophiophagus hannah*, Fishing Cat *Prionailurus viverrinus*, Striped Hyaena *Hyaena hyaena*, Sambar *Cervus unicolor* among others. The eastern boundary of Bhitarkanika supports the largest nesting ground in the world of the endangered Olive Ridley Sea Turtle *Lepidochelys olivacea* (Bustard 1976). Gopi and Pandav (2007) report the existence of 263 species of birds in Bhitarkanika of which 87 species have been recorded to breed here.

METHODS

Nests were located by walking along the river/creek banks. Most nests were found by searching areas known to have previously contained a nest. The extent to which the located nests reflect the total number of nests is not known. Upon location of the nests, the size of the nesting crocodile, distance from the nearest water source and number of wallows (body pits) made were recorded. Once the nesting crocodile abandoned the nest after successful rearing of the hatchlings, nest site characteristics were also recorded, which included broad identification of the vegetation patch and canopy cover above the nest site. Nesting adults were not caught and sexed because it was likely that they would abandon the nest. Tracks of only one size were present at each nest site, and it was presumed that this indicates the same individual in attendance. These tracks, combined with sightings, indicated crocodiles between 1.8 and 3.6 m in length, which is consistent with the size of adult females of *C. porosus*. Large tracks, presumably of adult males, were present along the river banks, but not at the nest sites. Disturbance scores of 0-3 were also assigned (Human activities > 91.44 m away from the nest were ranked as 0; human activities > 60.96 m away from the nest were ranked as 1; human activities > 30.48 m away from the nest were ranked as 2 and Human activities > 15.24 m away from the nest were ranked as 3). Nest monitoring was carried out every seven days till the nesting crocodile abandoned the nest site. Notes were also made on predator damage and flooding. Of the 54 located nests, only 39 nests were chosen for regular monitoring due to accessibility reasons. The clutch size and egg dimension data were collected only from those nests that were collected for a forest department managed hatchery. A total of four nests were collected in two years, two each in 2005 and 2006.

RESULTS AND DISCUSSION

Nesting period

Crocodylus porosus nests were constructed starting from the dry season through the wet season with the earliest on around April 20, 2005 and the latest on July 6, 2006 (Fig. 3). *C. porosus* nesting coincided with the annual wet season in Australia and west Java (Worrell 1952; Kopstein 1929; Neill 1971). In Sri Lanka, *C. porosus* nests during the hottest and driest period of the year (July/August), with hatching commencing at the start of the wet season (Deraniyagala 1939). But in Australia, where *C. porosus* starts building the nests in the wet season, this is markedly different (Webb *et al.* 1977). In Bhitarkanika, nesting commenced during the hottest and driest period of the year (April-July).

Nest dimensions and materials

The mean dimensions of the successful nests were: height 55.4 ±5.4 cm (n= 39, range 34 to 82), longest axis of base 182 ±12.2 cm (n=39, range 136 to 261). *Achrostichum aureum* and *Phoenix paludosa* leaves, both dead and fresh green ones accounted for the bulk of the nest materials. *Achrostichum aureum,* also called 'Mangrove Fern', grows in huge clumps, up to 2 m tall. The leaves are large (up to 2 m long), pinnate and bright red when young; fertile leaflets at the tip are covered with red-brown sporangia, and blades of sterile leaflets have a broadly rounded end terminated with a short tip. *Phoenix paludosa,* also known as 'Mangrove Date Palm', is a thorny unbranched, perennial palm, grows up to a height of 5 m or more with top foliages and sharp spines in the stem and leaf apices. The stems are used extensively in the construction of small huts as roof rafters and the framework of the wall. Worell (1952) and Ogilby (1904) described *C. porosus* nesting materials in Australia as "leaf mould" and "grape-vines grasses and other rubbish", respectively. Rushes, reeds and dead leaves are nest constituents in India and Myanmar (Worell 1952).

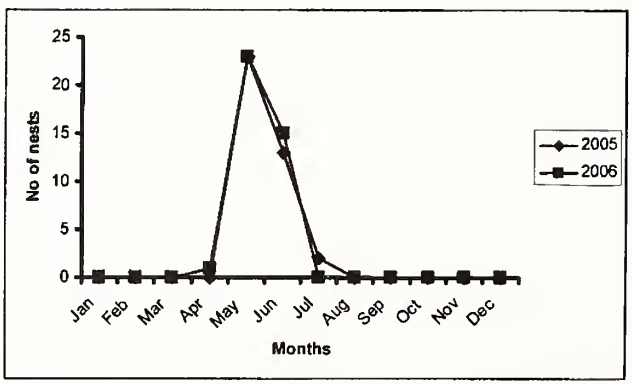

Fig. 3: Monthly breakdown of the new nests found for two consecutive years

Dead materials are used along with tall green grass or herbaceous aquatic plants, most commonly in the Philippines, Indonesia and Papua New Guinea (Neill 1971). In Java, the nests were constructed among 'man height' grass and small branches (Kopstein 1929). In Sri Lanka, there was an association between *C. porosus* and the plant *Lagenandra toxicaria*; *C. porosus* built their nests from it, and the eradication of the plant was closely followed by the disappearance of *C. porosus* from a particular region (Deraniyagala 1939). In Australia, *Ischaemum australe* var. *villosum* appears to replace *L. toxicaria* (Webb *et al.* 1977). Nests of *C. porosus* were similar in form and dimensions in all parts of its range (Neill 1971; Kopstein 1929; Deraniyagala 1939; Webb *et al* 1977).

Body pits/ Wallows

Crocodylus porosus builds body pits close to the nests and stays there till the end of the nesting season. Of the total of 54 nests located, 72.2% had wallows (mean = 1.1). The number of body pits varied between 1 and 4. Pearson correlation was performed to determine whether there is a change in number of body pits with distance from water source. The number of body pits increased with increase in the distance from water $p < 0.05$ (Fig. 4). Wallows beside nests were not mentioned in the study that was carried out in west Java (Kopstein 1929). In Sri Lanka, they are similar to those in northern Australia; some are shallow and seem to result from scraping material for nest construction, while others are deep and used as 'guard wallows' (Deraniyagala 1939). Wallows were found beside nests next to a permanent water source and nests at great distance from such a source (Webb *et al.* 1977).

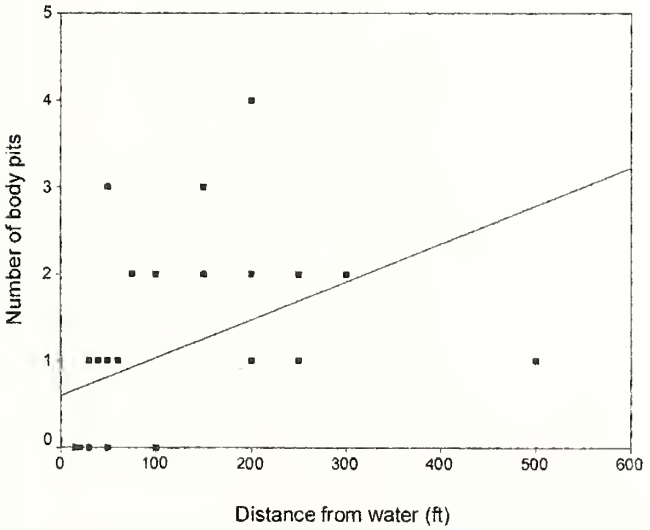

Fig. 4: Relationship between distance from water source and number of body pits made by nesting Crocodiles

Clutch size and egg morphometry

Of the complete clutches examined, the mean clutch size was 43.2 ±22.1 eggs (range 21-72), and the mean egg dimensions of clutch means were: egg length 71.95 ±5.5 mm (n = 70; range 64.2-86.5 mm); egg width 49.3 ±3.9 mm (n = 70; range 41.3-54.6 mm); egg weight, 121.5 ±14.0 gm (n= 70; range 68-138.72 gm). A total of six false nests were located and all the false nests were located at a distance less than 50 m from the completed nests with eggs. Our data on egg numbers and sizes are consistent with other studies conducted elsewhere (Kopstein 1929; Deraniyagala 1939; Webb *et al.* 1977; Worrell 1952). The between-nests variation was much greater than within-nest variation (Kopstein 1929). Egg size (length and width) between-nest variation were greater than within-nest variations ($p = 0.004$).

False Nests

False nests had the same structural composition as that of the completed nests with eggs. False nests were made by small sized crocodiles (1.8-2.4 m). The building of nests without eggs is not clearly understood. This behaviour has been observed in northern Australia (Webb *et al.* 1977). These nests are complete and in all respects resemble nests with eggs, suggesting they may be false nests. The most likely explanations are the following: (1) They are made by immature/ young females. (2) They have been disturbed by humans or other disturbances. (3) The site is not suitable, or change in weather has caused the site to be abandoned.

Predation and flooding of nests

Bhitarkanika and Ragadapatia forest blocks had higher disturbance in terms of human activities that include illegal fishing, honey collection and fuel wood collection. Dangamal forest block was the least disturbed zone due to the presence of the forest department office near the nesting areas (Fig. 5). Pearson chi-square tests showed significantly higher predation ($p < 0.01$) in higher disturbance areas.

Predation was independent of tree and shrub abundance across the nests ($p = 0.400$); however, predation was relatively higher in the *Achrostichum* patches than in the *Phoenix* patches ($p = 0.001$), which was evident while making comparisons with the forest block on predation. Bhitarkanika and Ragadapatia forest blocks accounted for higher predation due to nest building in the *Achrosticlium* patches compared with Dangamal Forest Block where nests were built in *Phoenix* bushes. As *Achrosticlium* patches are softer it is easier for predators to gain access to the nests in them, but in *Phoenix* patches access is relatively difficult for predators due to the spine and thorns associated with this patch. Predation was higher for the nests that were built closer to the water source

than for the nests that were built more inland (p = 0.001). Mother crocodiles that build nests closer to the water keep entering the water source (creek, nalla/river) upon even a slight disturbance, and they construct fewer wallows; however, nest surveillance was higher for the crocodiles that built the nests well inland and thereby prevented predation.

Observations on predated crocodile nests showed signs of two major predators in Bhitarkanika namely Wild Boar (*Sus scrofa*) and Water Monitor Lizards (*Varanus salvator*). Predation on *C. porosus* eggs was minimal in northern Australia (Webb *et al.* 1977). Varanid lizards were found to be the major predators of *C. niloticus* eggs (Cott 1961; Pooley 1969).

The effect of flooding on *C. porosus* nests in northern Australia is catastrophic (Webb *et al.* 1977). Flooded nests were also found in Java (Kopstein 1929), whereas in Sri Lanka flooding of nests posed very little danger to the nests (Deraniyagala 1939). In Bhitarkanika, earlier nesting removes the danger of flooding of nests.

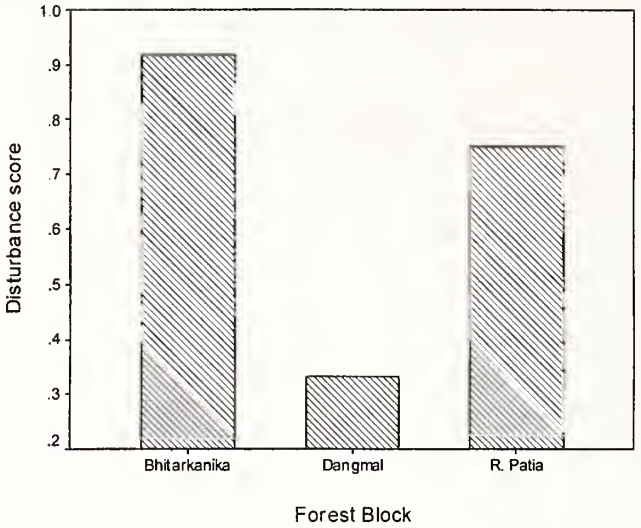

Fig. 5: Relationship between disturbance score and forest block

CONCLUSION

Currently the Orissa Forest Department still manages the crocodile hatchery in Dangamal forest block. During the last two decades more than 5,000 eggs were collected from the forest blocks of the Sanctuary of which 2,695 hatchlings hatched (51%) and 2,488 crocodiles survived (92%). These eggs have been collected from wild nests randomly over the years. Currently two to four wild nests are excavated annually and brought to the hatchery for its rear and release programme. This study clearly shows predation to be higher in the softer *Acrostichum* patches and in the nests that are built very close to a water source (rivers, creeks and nallas). Efforts should be made to carry out further collections in coming years from these nests which have lower survival expectancy than in nests collected randomly. Empirical studies pertaining to hatchling and juvenile recruitment, and survival rates and behavioural ecology could be carried out in future in the Bhitarkanika mangroves, considering the existing gap in the knowledge of Saltwater Crocodiles. With the prospect of increasing man-animal conflicts in Bhitarkanika, the information obtained will pave way for a robust scientific carrying capacity assessment for Saltwater Crocodiles in Bhitarkanika in the days to come.

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NEW DESCRIPTIONS

A NEW FAIRY SHRIMP SPECIES, *BRANCHINELLA NALLURENSIS* FROM SOUTH INDIA[1]

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The current study identifies a new fairy shrimp, which belongs to the genus *Branchinella* from Chengalpattu, Tamil Nadu, India. Morphological variation was observed in frontal appendage, second antennae, penal structure in male and egg ornamentation in female justifying this as a new species, *Branchinella nallurensis*. The variation observed in the present study was confirmed by comparing with the well known species, *B. kugenumaensis* (Japan) and *B. madurai*.

Key words: *Branchinella kugenumaensis*, *B. madurai*, *B. nallurensis* sp. nov., egg ornamentation, new species, second antennae, penal morphology

INTRODUCTION

Fairy shrimps belong to the genus *Branchinella* (Anostraca: Thamnocephalidae) Sayce 1902, are widely distributed all over India (Linder 1941; Quadri and Baqai 1956; Tiwari 1965; Bernice 1972). *Branchinella kugenumaensis* (Ishikawa 1895) is originally identified as endemic from Japan and is now reported to occur in majority of Asian countries. Based on the size, number of protruberances in the second antennae and frontal appendage in Japanese population, Raj (1951, 1961) described the Indian population as a new variety, *B.k.* var. *madurai*. The status of B.k. var. *madurai* has been rejected by various researchers (Radhakrishna and Prasad 1976; Belk and Esparaza 1995). Despite these rejections it gained species status due to the tremendous contribution of Brendonck and Belk (1997), who named it as *B. maduraiensis* Raj. Recently, the nomenclature for this species is further corrected as *B. madurai* (Martin and Boyce 2004). Based on a detailed morphological comparison to *B. kugenumaensis* and *B. madurai*, *B. nallurensis* nov. sp., is identified and reported in this study as a natural population of *Branchinella*.

MATERIAL AND METHODS

About twelve animals were collected from Nallur village (12° 42' N; 80° 01' E), Chengalpattu, Tamil Nadu, India during May 1997. The species was collected repeatedly during 1998 and 1999, and invariably showed the same morphology as the species reported from Madurai and Japan. For observation purposes, they were brought to the laboratory and fixed in 4% formalin. Holotype male (3.1 cm) and females (3.2 cm) (UM/DZ/NM/FS 150 to 153) were used to study the morphology. Total of five males (2.8-3.6 cm) and seven females (3.0-3.4 cm) (paratypes) were observed and some specimens were deposited in the Zoological Survey of India (Cat # CA1ZSI/SRS).

RESULTS AND DISCUSSION

Frontal appendage is divisible into three regions (Fig. 1). The first part (basal) consists of 17-22 protruberances, spiniform proximally and digitiform distally. Spines are seen at the base of frontal appendage and in between the second antennae. The second part (middle) branches out into two, one at the upper region and the other in the lower part armed ventrally with two rows of 16-22 widely spaced tubercles (Fig. 1). Rami, the third part consist of 3-4 strong spines in their ventral region. Each ramus is long, ensiform medial side branch with spines on entire surface and one prominent spine at the base. Lateral side branch (2L) equals to the main branch (1M) and with spine at the tip (Figs 1, 2).

Dorso-lateral surface of the second antennae consists of about 22-27 digitiform tubercles (Fig. 1). The second antenna is divisible into apical (aj) and basal joint (bj) (Figs 1, 3). Basal joint consists of a row of 3-5 tubercles situated medially (Fig. 1). Medial antennal process (MAP) reaches to the middle distal joint of antennae and are set with 9-10 long ventro-medial protuberances of which 5-6 are bifid and located ventro-medially, 3 are anvil-shaped and 1 is digitiform located distally (Figs 1, 3). Eight long spiniform protuberances observed, are located on the dorso-medial surface (Figs 3, 4).

Antennal morphology of several species has been proved as a valid character in taxonomy (Daday 1910; Linder 1941; Brtek 1974; Maeda-Martinez *et al.* 1995; Velu and

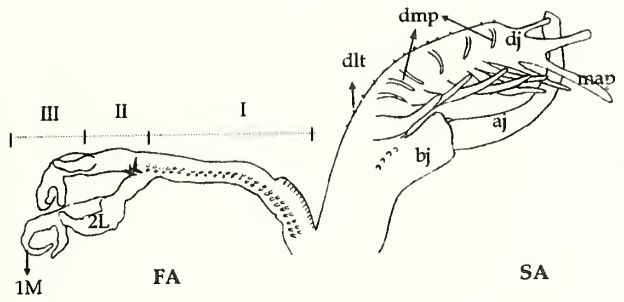

Fig. 1: Camera lucida diagram showing the frontal appendage and second antenna (outer and inner view) of male *Branchinella nallurensis*. sp. nov. aj – apical joint; bj – basal joint; dj – distal joint; 1M – 1 main branch; 2L – lateral branch; sp – spines; FA – frontal appendage; SA – second antennae; map – medial antennal processes; dmp – dorso-medial processes; dlt – dorso-lateral processes; I, II, III – 1st, 2nd, 3rd Segment

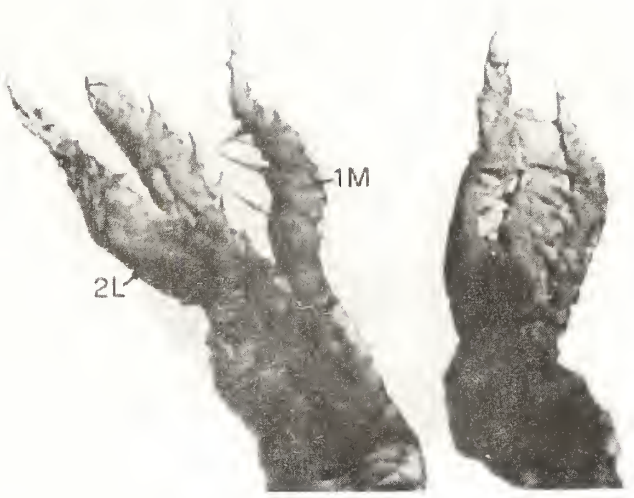

Fig. 2: Light microscopic photograph showing the rami of frontal appendage in male. 1M-main branch; 2L-side branch

Fig. 3: Light microscopic photograph showing the inner lateral view of second antenna of male *Branchinella nallurensis* sp. nov.

Fig. 4: Higher magnification showing the dorso-medial protuberances (p) on the second antenna

Munuswamy 2005). *B. madurai* Raj gained species status mainly based on the morphology of male second antennae, genital structure and egg ornamentation. A significant difference in the size of 1M branch of frontal appendage and morphology of ventro-medial protruberances in the antennal process was observed (Brendonck and Belk 1997). Using the same criteria, we distinctly show the variation between *B. nallurensis* and other species (Tables 1-3). In addition, the side branch 2L of the frontal appendage reach the tip of main branch 1M, the digitiform protuberances on the medial side of basal antennal joint resembles that of *B. madurai*. The third section, ramus, in the *B. nallurensis* show spines on their

Table 1: Morphological variations observed in the frontal and second antennae of *Branchinella* species

	B. kugenumaensis	*B. madurai*	*B. nallurensis* sp. nov.
Dorso-medial process	6 spiniform	7 digitiform	8-9 spiniform
Medial antennal process	10 digitiform protuberances, 7 ventro-medial, 3 distal	8 long protuberances, 5 bifid ventro-medially, 3 anvil-shaped distally	9 long protuberances, 6 bifid, 3 anvil-shaped distally
Medial side of basal joint	6 tubercles	3 small tubercles	8-10 tubercles

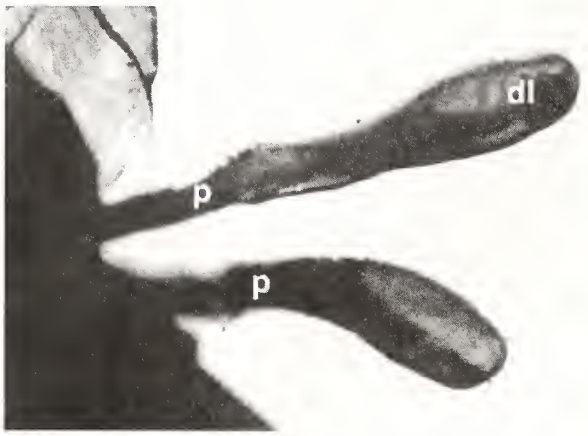

Fig. 5: Photograph showing the penal morphology of male *Branchinella nallurensis* sp. nov. dl – distal lobe; p – penis

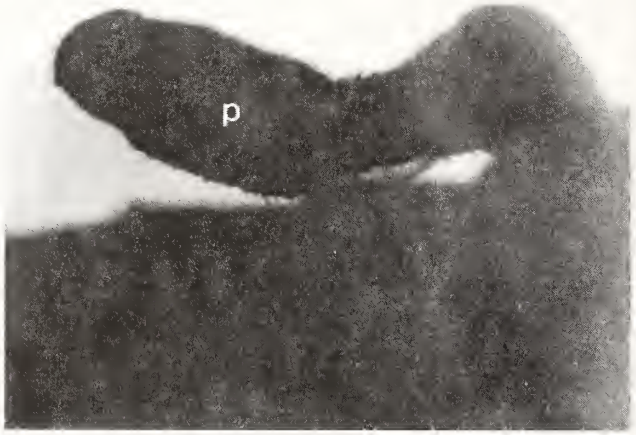

Fig. 6: Lateral view of the penal morphology (p) observed in male *Branchinella nallurensis* sp. nov.

surface, which is seldom found in *B. madurai*. Dorso-medial protuberances range to 6 in *B. madurai* and *B. kugenumaensis*, whereas in *B. nallurensis* sp. nov. the protuberances are 8 in number. Moreover protuberances are spiniform in *B. kugenumaensis* and *B. nallurensis* sp. nov.; they are digitiform in *B. madurai*. Basal joint possesses 3-5 small tubercles in *B. nallurensis* sp. nov., whereas *B. madurai* and *B. kugenumaensis* possess 6-11 and 5-8 tubercles, respectively (Table 1).

Male genital morphology shows unique characteristic features. The basal part of penis is long, widely separated and with a pair of lateral linguiform outgrowth. A single medial out-growth was seen in the inner side of non-retractile basal part of penis. Eversible part of penis is lengthier and bulged compared to that of the basal part and laterally set with a long row of prominent spines, which are sharp and flat structures (Figs 5, 6). Ventral, medial and dorsal surfaces are covered with spinules, which are denser at the distal region compared to the basal part. The penile structure is club shaped and extends up to the 3rd abdominal segment. In

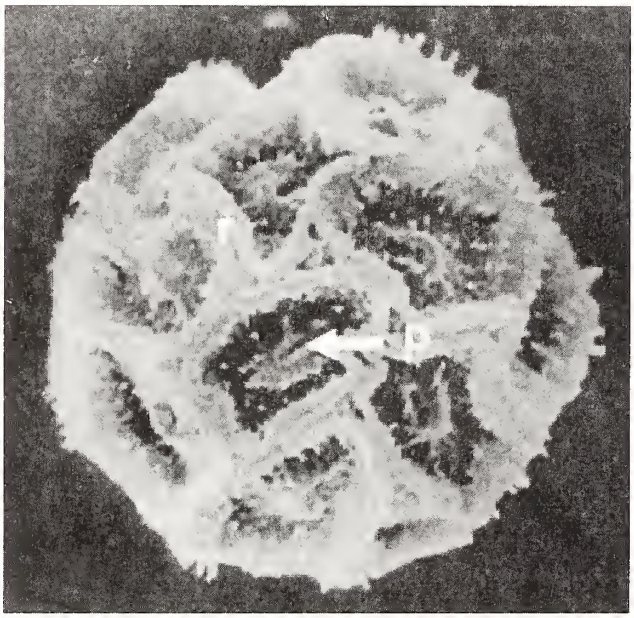

Fig. 7: Scanning electron micrograph showing the egg ornamentation of the new species *Branchinella nallurensis* p – pore; r – ridges

Table 2: Morphological variations observed in the peneal structure of different *Branchinella* species

B. kugenumaensis	*B. madurai*	*B. nallurensis* sp. nov.
Basal part shorter, widely separated with small medial process proximally	Basal part short widely separated with small medial process proximally	Basal part short widely separated with small medial process proximally. Eversible part is bulged compared to that of the basal part
Lateral set with a long row of prominent spines, conical near base	Conical lateral lobes almost as long as basal part. Laterally with long row of spines	Conical lateral lobes in the distal part
Sharp and flat in middle region scale like distally	Spines conical at proximal, scale-like distally	Lengthy spines, scale-like distally

Table 3: Morphological variations observed in the cyst of *Branchinella* species

	Overview	Ultra structure
B. kugenumaensis	Egg shell with irregular polygon	Minute pores on their surface
B. madurai	Egg shell with lip-like units covered with denticles	Denticles end with multiple spines
B. nallurensis sp. nov.	Egg shell with hexagonal ridges with a volcano-like structure in the centre	With single prominent pore with spine on the ridges

branchinellids, the morphology of penis is only occasionally presented (Quadri and Baquai 1956; Raj 1961; Tiwari 1971; Belk and Sissom 1992; Brendonck and Riddoch 1997), and is rarely described due to the difficulties in preparing specimens, and drawing and orienting the penile structures. Based on the penile structure (Table 2) we suggest that *B. kugenumaensis* and *B. madurai*, might belong to the North American species group which includes *B. sublettei* (Sissom) and *B. alachua* (Dexter); whereas, *B. nallurensis* resembles *B. ondonguae*, in which the basal part is slender and long, swollen distally (Brendonck 1997). Brendonck (1995a, 1997) proved the penile morphology as a valuable taxonomic tool in thamnocephalidae and suggested use of this characteristic to diagnose each branchiopodid genus or when erecting a new genus, apart from conventional characters. Moreover, the relevance of using penile morphology to distinguish anostracan genera was substantiated by referring the co-evolutionary nature of the penis (Brendonck 1995b).

Female fairy shrimp lacks frontal appendage. Second antenna is flat, small and rectangular unsegmented structure. Brood pouch is pear shaped and elongate up to the 3rd abdominal segment. Egg measures about 275-290 µm in diameter and scanning electron microscopic (SEM) study on the egg ornamentation reveals pentagonal shaped ridges with a prominent volcano-like pore in the center (Fig. 7, Table 3). Various studies have shown the importance of egg morphology while defining natural groups, which can provide taxonomic information (Thiery *et al.* 1995; Velu and Munuswamy 2005), due to their independent sexual selection (Belk *et al.* 1998).

Present taxonomic investigation clearly shows a marked variation in the male second antennae, penile and egg morphology in all three species of *Branchinella*. This led us to erect a new species, *Branchinella nallurensis* sp. nov. under the genus *Branchinella*. Besides this, through detailed molecular analysis by random amplified polymorphic DNA (RAPD) demonstrates and provides supportive information on their new species status (Velu 2001).

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DESCRIPTION OF A NEW SPECIES OF *CERCERIS* LATREILLE (HYMENOPTERA: SPHECIDAE: PHILANTHINAE: CERCERINI) ALONG WITH A NEW RECORD FROM INDIA[1]

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A new species of *Cerceris* Latreille from India, namely *Cerceris delhiensis* is described and illustrated. Another species, *C. lunata* is recorded for the first time from India. *C. lunata* is also redescribed with emphasis on certain additional characters.

Key words: *Cerceris*, Hymenoptera, Sphecidae, Philanthinae, Cercerini, India

INTRODUCTION

Family Sphecidae constitutes one of the most important groups of predacious solitary wasps within the aculeate Hymenoptera. The first modern classification of Sphecidae was provided by Kohl (1896). At present, it has 11 subfamilies of which Philanthinae is the largest, with around 1,100 described species under 11 genera and 6 tribes.

Tribe Cercerini of subfamily Philanthinae includes small to large wasps, which are relatively common and widespread, characterized by colourful markings and coarsely sculptured integument, and are commonly found on or about flowers. All species are ground nesting and provisions are made with different kind of preys. It is interesting that the Cercerini mainly feed on adult Coleoptera, although Hymenoptera are used by a few species.

Genus *Cerceris* Latreille the largest of the genera of Philanthinae, with about 850 species recorded so far, is well represented in all major zoogeographical regions. The genus *Cerceris* was erected by Linnaeus (1758) as *Sphe*x, by Fabricius (1775) as *Crabro*, and by Fabricius (1793) as *Philanthus*. Finally, it was Latreille (1802) who designated the genus as *Cerceris* based on the type species *Philanthus ornatus* Fabricius, 1790.

This genus can be identified by the following characters: clypeus of the female often with distal teeth or other projections, ocellocular distance not reduced, subantennal sclerite nearly always defined by lines from antennal sockets through tentorial pits to clypeus, pronotum raised, but often appressed to scutum, outer vein of the submarginal cell III joining marginal cell at or before its outer third, submarginal cell II nearly always petiolate in front, first gastral segment usually forming a peduncle or sometimes a narrow petiole, terga without median or submedian transverse grooves, female sternum VI usually deeply cleft at apex and male pygidial plate not denticulate laterally.

Cerceris delhiensis sp. nov. (Figs 1-7)

Description

Male: Length: 8.75-9.75 mm.

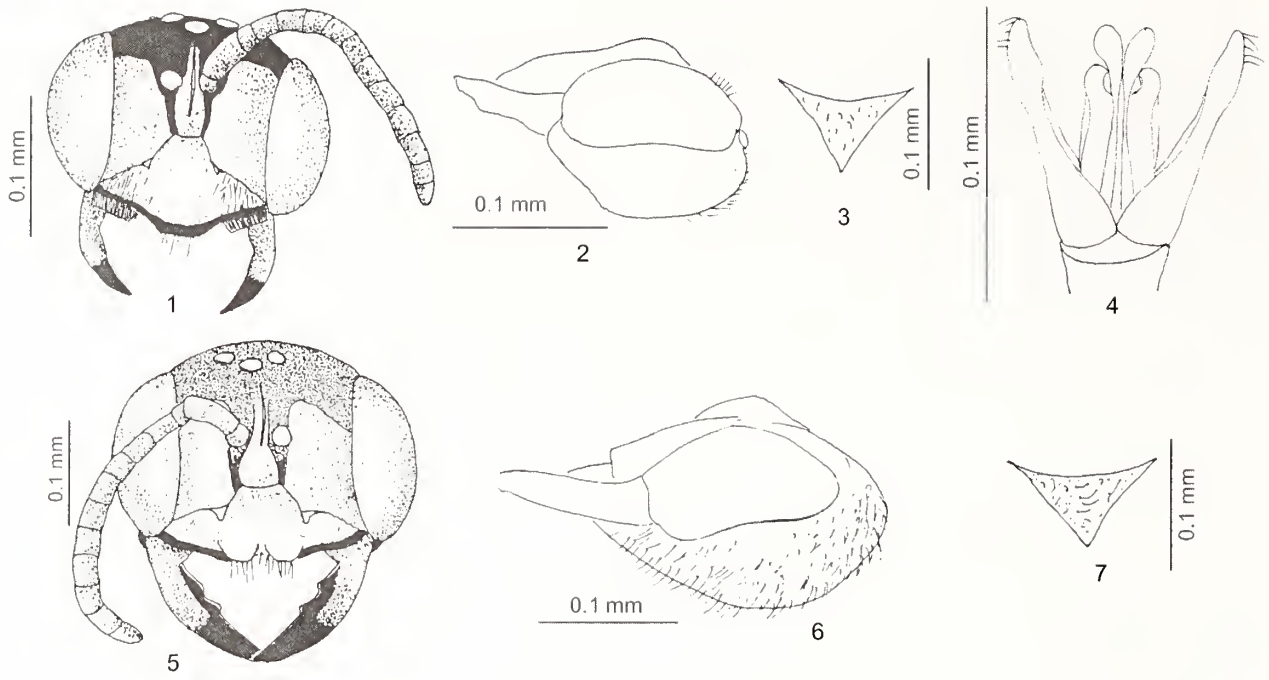
General coloration: Black; the following yellow: basal three-fourth of mandibles, clypeus except at median apical region, scape beneath, no stripe to anterior ocellus, supraclypeal area, side of front to above antennal fossa, streak on interantennal prominence, faint markings behind ocelli, medially interrupted band on pronotal disk, band on scutellum, post scutellum, all legs with a few faint brown markings, except for dorsal apex of hind tibia, base of mid tibia, third, sixth abdominal terga, faint band on apex of fifth sternum; the following parts / areas yellowish brown: second abdominal platform, basal part of third, fourth and fifth sterna: the following reddish brown: propodeum, all abdominal terga except apical carina and basal portions of all segments.

Head broader than thorax; median apical region of clypeus transverse, clypeus, supraclypeal area and median lobe reduced; sub-antennal suture well developed, long and narrow; smooth and shiny head region with coarse shallow punctures, pubescence scarce expect at lateral region of clypeus.

Thorax smooth and shiny with a few coarse shallow punctures; scrobal sulcus not deep, carination above the same missing; propodeal enclosure glossy, smooth, punctation like that of thorax, a few long hairs at lateral region; median groove shallow, lateral groove well developed. Inner margin of hind coxa with well developed carina.

Pubescence and punctures on abdomen like that of thorax; basal plate of second, third and fourth abdominal sterna smooth and shiny with fine punctures, declivous laterally, apical plate of entire abdominal sternum with coarse shallow punctures and long silvery pubescence.

Genitalia: 2.31 mm long; elongated; gonostyli 2x broader at base than at apex, its sides narrow at middle but



Figs 1-7: *Cerceris delhiensis* sp. nov.
Holotype male head: 1. dorsal view, 2. lateral view, 3. propodeum, 4. genitalia; Female head: 5. dorsal view, 6. lateral view, 7. propodeum

widening towards apex, inner margin emarginated slightly at apex, apex of gonostyli with a few sensory setae; aedeagus only 0.92x as long as gonostyli, aedeagal lobes touching each other at middle, but diverging at apex and ending in a club shaped aedeagal head; volsella 0.76x as long as gonostyli, outer margin depressed at middle and inner margin emarginated at apex.

Female: Length 11.15-12.1mm.

General coloration: Brown; the following yellow: scape beneath, basal two-third of mandibles, clypeus except at apical margin, supraclypeal area, streak on interantennal lamella, scape beneath, side of face to well above antennal fossae, entire mesopleuron, third abdominal terga, basal plate of sterna; black oblique strip running from above antennal fossa to anterior inner margin of eyes. All abdominal terga and sterna brown. Apex of forewing with infumation beyond marginal cell.

Mandibles with two prominent teeth; median apical region of clypeus sinuate with blunt lateral tooth, with stiff long hairs on inner margin, supraclypeal and side of front slightly protuberant. Long silvery pubescence all over head, thorax, abdominal terga and sterna.

Scrobal sulcus shallow in thorax without carina in lower margin of upper part of mesopleural plate. Propodeal enclosure smooth and shiny. Basal platform of abdomen well developed in second abdominal sternum.

Distribution: INDIA: Delhi, Bihar

Materials Examined: **Holotype:** India: Delhi, ♂, 17.viii.1960, Coll., Menon, on wing. **Paratypes**: Delhi: IARI, 4♂♂, 17.viii.1960, 19.viii.1960, 4.ix.1960, 4.ix.1960, Coll., Menon, on wing; Delhi, ♂, 2.vii.1956, Coll., D.S. Bisht on Lucerne. Bihar, Benhar, 2♀♀, 3.vii.1919, 25.x.1919, Coll., H. Inglis; Delhi: IARI, 3♀♀, 10.ix.1956, 10.ix.1956, 17.viii.1960, Coll., Menon, on wing.

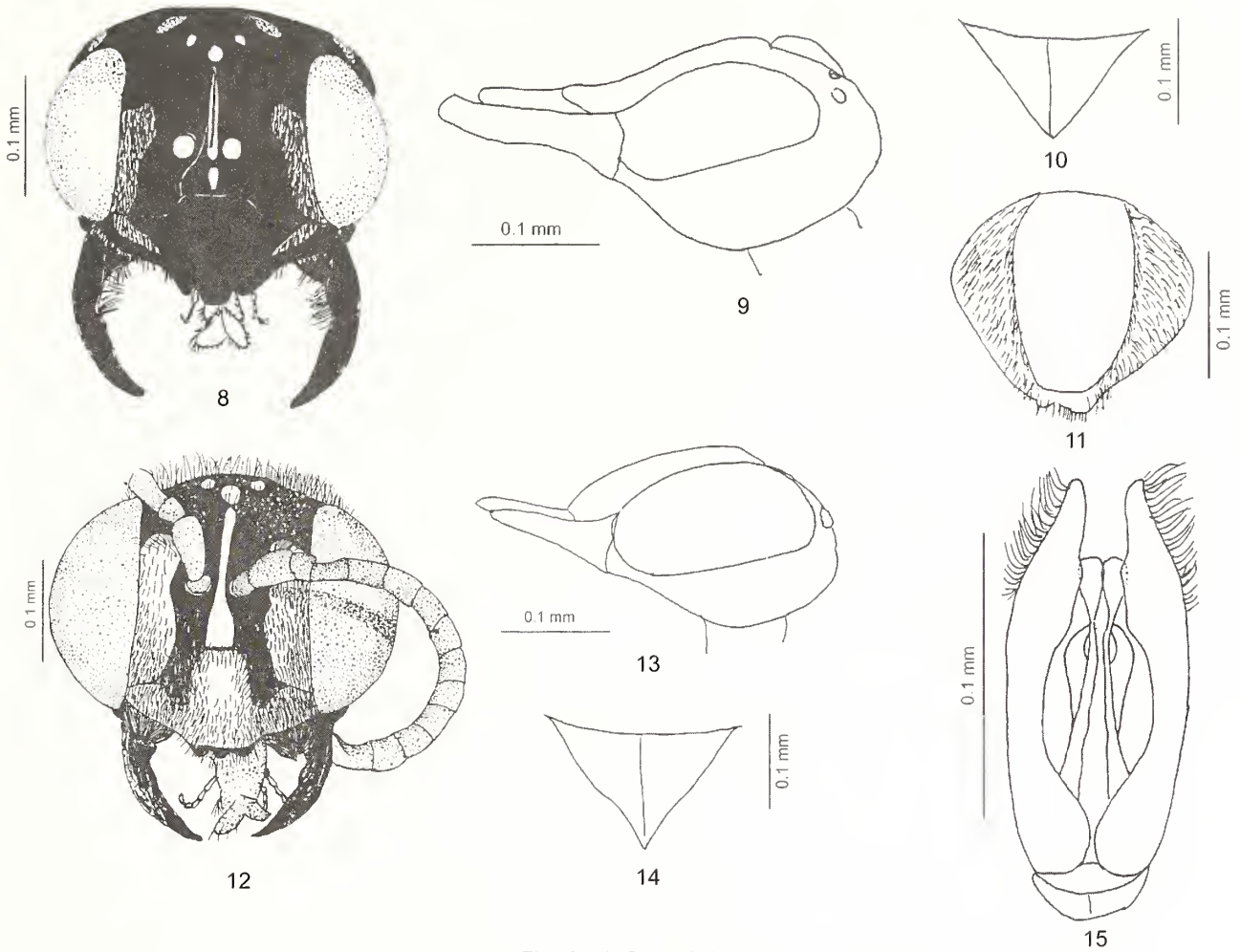
Remarks: Males of this species resemble those of *C. instabilis* except in the general body coloration which is brownish, presence of concave band behind ocelli and temple, band on scutellum, sharp scrobal sulcus and also variations in male genitalia.

Etymology: This species has been named *delhiensis* based on the type locality.

The type specimens of *Cerceris delhiensis* have been deposited at the National Pusa Collection, Division of Entomology, Indian Agricultural Research Institute, New Delhi, India 110 012.

Cerceris lunata Costa (Figs 8-17)

C. lunata hitherto known only from Europe and USSR is being recorded for the first time from India. Further this species is being redescribed with emphasis on certain additional morphological characteristics like distribution pattern of punctation on head, thorax and abdomen, pubescence on the facial area, nature of sculpture on propodeum and propodeal enclosures, extent of development



Figs 8-15: *Cerceris lunata*
Female head: 8. dorsal view, 9. lateral view, 10. propodeum, 11. pygidial plate; Male head: 12. dorsal view, 13. lateral view, 14. propodeum, 15. genitalia

of mesopleuron, nature of scrobal sulcus, nature and extent of development of carina on mesopleural plate, extent of development of carina on inner margin of hind coxae, and shape of pygidial plate. The description has been adequately supported with illustrations.

Female: Length 15.45 to 16.5mm

General coloration: Black; the following yellow: spot on outer proximal part of mandibles, long strip at lateral region of front to above antennal fossa, apical lateral region of clypeus, narrow strip from anterior frontal lobe to just beyond inter antennal prominence, pair of elongated spots behind ocelli, pair of transverse band on anterior region of temple, pair of small spots on pronotal disk, small spot on tegula, anterior surface of fore tibia, midtibia, posterior margin of all tibiae, middle region of basitarsus, medially separated broad spot at apex; the following black: head, antennae, thorax, all legs, propodeum, base of first abdominal segment; the following brown: apex of wing with well diffused infumation in both pair of wings, apical carina of each segment from second to fifth and pygidial plate. Abdomen entirely reddish brown.

Mandibles slender, inner margin of mandible without teeth; median apical region of clypeus extended forward and subtruncate, emarginated tridentate with small blunt lateral tooth; clypeus and supra clypeus flat, shiny with small dense silvery appressed pubescence all over except on median lobe of clypeus and frontal lobe; punctures shallow and sparse on vertex.

Scrobal sulcus on thorax shallow, very dense strong punctures on entire tergum of thorax, pleuron and sternum; sternum with silvery pubescence. Apophyseal pit at middle of metasternum, very long silvery pubescence on coxa, trochanter and hind leg.

Propodeal enclosures raised, smooth with sparse pubescence on lateral region; transverse rugulae not reaching middle at anterior region; median and lateral grooves well developed.

Coarse deep punctures and long silvery hairs on first abdominal segment; second segment shiny with shallow punctures and small yellowish pubescence all over.

Male: 13.25- 14.45mm

General coloration: The following reddish yellow: basal half of mandible, clypeus, supra clypeus, streak on inter antennal carina, side of front to well above antennal fossa extending to median ocellus from inter antennal carina, antennae, big spot on temple, medially interrupted on pronotal disc, tegula, scutum and scutellum, all legs except at bases of coxae, spot above and below scrobal sulcus, lateral area of propodeum, propodeal enclosure, entire second and third abdominal segments and basal platform of abdominal sternum; the following black: vertex, scutellum, first abdominal segment, fourth and fifth abdominal terga except basally and medially. Pygidial plate brown.

Median apical region of clypeus slightly arched, shallow longitudinal depression at middle from base to apex; clypeal brush well developed laterally. Antennae slender with sharply pointed last flagellar segment.

Punctures on thorax as in female, scrobal sulcus well developed, wings transparent unlike in female, apophyseal pit at middle of metasternum, carina at inner margin of hind coxa. Propodeal enclosure well raised with fine punctures.

Genitalia: Gonostyli 1.52 mm long; outer four-fifth of the gonostyli from base to apex slightly curved, basal one fifth of gonostyli broad and rounded, middle portion relatively slender but widening before finally tapering towards apex, outer distal one third of the gonostyli provided with long and curved sensory hairs; aedeagus 0.71x as long as gonostyli, aedeagal arms highly divergent at base, but converging later and ends in a pair of inflated structures; volsella 0.55x as long as gonostyli, its outer margin depressed near middle and inner margin emarginated near apex.

Distribution: INDIA: Bihar: Benhar, Chapra.

Materials Examined: Bihar; Chapra, ♀, Coll. Mackenzie; Chapra, 8 ♂♂, H/4710, H/4769, H/4836, Coll. Mackenzie; Bihar; Benhar, ♂, 27.vii.1919, Coll. H. Inglis.

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MISCELLANEOUS NOTES

1. FIRST RECORD OF LESSER FALSE VAMPIRE *MEGADERMA SPASMA* (LINNAEUS, 1758) IN MADHYA PRADESH, INDIA[1]

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The Indian False Vampire *Megaderma spasma* is a carnivorous bat occurring in the Indian subcontinent and in Southeast Asia. In India, it has been reported from the states of Assam, Mizoram and West Bengal in the east, and Maharashtra, Goa, Karnataka, Kerala and Tamil Nadu in the south, as well as the Andaman Islands (Fig. 1). Though specimens of *M. spasma* have been collected from Andhra Pradesh state, site specific information remains scanty (Bates and Harrison 1997). However, there is no existing record of its occurrence from central, western and northern parts of the country. Recently I saw this species for the first time in Madhya Pradesh state, central India (Fig. 1).

It was in the late afternoon of February 27, 2005, when I, along with my colleague Mr. Anant Khot, explored bat roosts along the southern bank of River Narmada near Bheda Ghat, a tourist hotspot about 15 km west of Jabalpur in Madhya Pradesh. The Lamheti village is situated 2 km east of Bheda Ghat on the southern bank of the Narmada, and is surrounded by lush green vegetation. On the eastern periphery of this village is situated a temple of Lord Shiva (23° 06' 11.79" N; 79° 50' 45.28" E, at 396 m above msl), and a dilapidated building in its premises served as a mixed roost for two microchiropteran, the Greater False Vampire *Megaderma lyra* and the Lesser False Vampire *Megaderma spasma*. We approached this roosting site at 1630 hrs along with two local children and found a mixed colony of bats roosting on the ceiling in a partially dark portion of this building. The group consisted of around 80 individuals, but the proportion of each species could not be assessed. A few individuals hung separately while others roosted close to each other forming a cluster at the centre of the ceiling. They were disturbed by our entry, and the bats moved out one by one to an adjoining building, but I could catch three of them in a hoop net. All three individuals were studied for morphological measurements (Table 1) and studied closely for key characteristics and released back. Our investigations showed that one of these individuals was a *Megaderma lyra*, whereas the other two were *Megaderma spasma*.

Though *Megaderma lyra* is distributed widely all across India, *M. spasma* was previously understood to be restricted to the southern and eastern parts of the country (Fig. 1). The current finding represents the first record of *M. spasma* from the state of Madhya Pradesh. It significantly extends the distribution range of this species from west to central India, 371 km from the nearest site, Chanda in Maharashtra from where it has been reported earlier (Bates and Harrison 1997). Although Wroughton (1913) did find the two species together

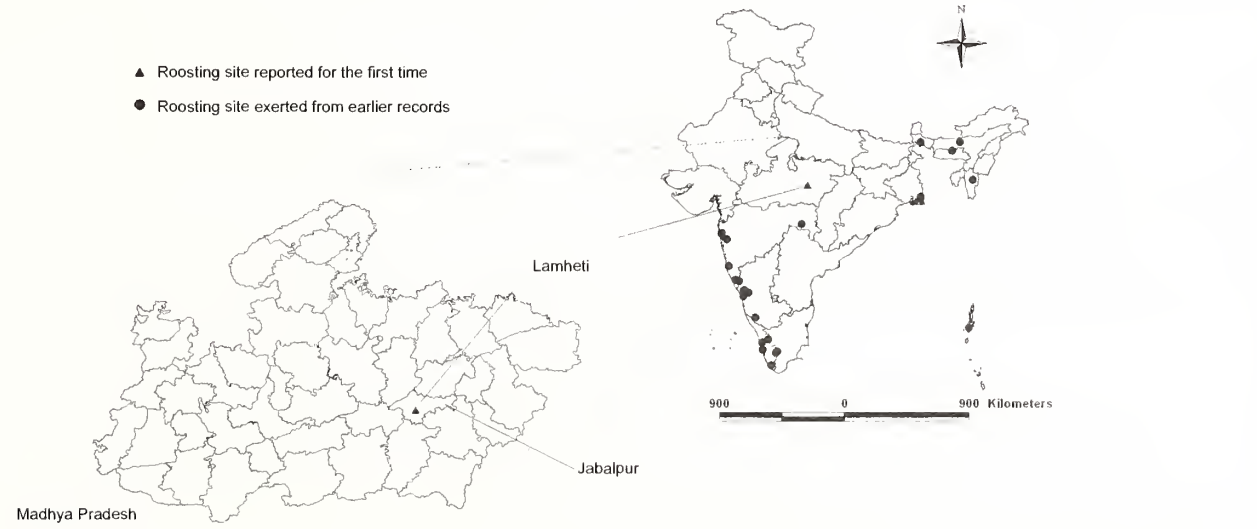

Fig. 1: Distribution status of Lesser False Vampire *Megaderma spasma* in India with old and newly recorded roosting sites

Table 1: Morphometric measurements (in millimetres) of *Megaderma lyra* and *Megaderma spasma* specimens caught from the temple roost in Lamheti village in Jabalpur Madhya Pradesh

Name of the body part	*Megaderma lyra*	*Megaderma spasma*	
	Male (n=1)	Male (n=1)	Female (n=1)
Head and Body length	80.2	65.2	66.3
Hind foot	15.9	14.9	14.8
Forearm	64.3	55.7	55.5
Ear	36.7	34.2	34.6
Wing span	410.4	308	311
Nose leaf	9.4	6.1	6.2

inside a temple in Karnataka, the co-existence of *M. lyra* and *M. spasma* has been rarely seen in India.

ACKNOWLEDGEMENTS

I extend my sincere thanks to my colleague Mr. Anant Khot of the Bombay Natural History Society (BNHS) for assisting me in field work and Mr. Mayank and Mr. Rahul of Lamheti village for guiding me to the above-mentioned bat roost. I am also grateful to Dr. Asad R. Rahmani, Director, BNHS, for his academic support to carry out this work.

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2. SECOND RECORD OF ALBINO FIVESTRIPED PALM SQUIRREL *FUNAMBULUS PENNANTI* WROUGHTON FROM UDAIPUR, RAJASTHAN[1]

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The Fivestriped Palm Squirrel *Funambulus pennanti* has distinct five pale strips on its grayish-brown or olive-brown body (Menon 2003; Prater 2005). A number of local races are recognized on the basis of differences in the lightness or darkness of the coat, or variations in the tones of the dorsal strips (Prater 2005). Unlike the characters mentioned in the guide books, we sighted a solitary, white Fivestriped Palm Squirrel in the residential area of north Udaipur (Rajasthan) from mid-July 2005. On close observation of the animal, we found that the Squirrel was albino with only a small brownish patch in the middle of the dorsal side of the body (Eds: photographic evidence provided); the eyes were red. This is the second case of albinism in the Fivestriped Palm Squirrel from Rajasthan. Although, the first record of albino Fivestriped from Rajasthan was by Sharma (2004); albinism in the Fivestriped Squirrel has been reported only thrice in India (Mahabal *et al.* 2005).

According to Mahabal *et al.* (2005), albinism is said to be rare in rodents. This is also evident from the earlier works (Rajgopalan 1967; Pradhan 1975; Chaturvedi and Ghosh 1984).

The reported albino squirrel was sighted throughout a cloudy day but its movement was restricted to morning and evening hours on sunny days. This albino individual lived in a house under construction

The solitary individual was very alert. As soon as we approached, it would escape. A distance of more than 6 m was maintained while taking observations and photographing. How long it may be sighted after the house is occupied cannot be predicted.

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We thank Dr. Satish Kumar Sharma and Dr. Pratap Singh for valuable discussions. Also, we are grateful to Mr. Praveen Sharma and Mr. Shambhu Sharma for technical assistance in photography and videography.

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3. OCCURRENCE OF ASIATIC BRUSHTAILED PORCUPINE *ATHERURUS MACROURUS* (LINN. 1758) AT MIZORAM, INDIA[1]

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The Asiatic Brushtailed Porcupine *Atherurus macrourus* is known to exist in Assam, India. Ellerman and Morrison-Scott (1951) had recorded its distribution as Assam (India), Tenasserim (Myanmar), China, Indo-China, Thailand and Malaysia.

According to Choudhary (1997) *Atherurus macrourus assamensis*, a subspecies of the Asiatic Brushtailed Porcupine is found in India. This is also endorsed by Molur *et al.* (1998). In the CHECKLIST OF INDIAN MAMMALS, Nameer (2000) has also mentioned Assam as its known distribution limit. Thomas (1921) had described the specimen of Asiatic Brushtailed Porcupine collected from Assam by Wells, during the Mammal Survey of India. In his report, "Scientific results from the Mammal Survey", he had described it as a new species *Atherurus assamensis*. But subsequently, it was given the status of subspecies *assamensis*. Currently, the subspecies *assamensis* is also considered as a synonym of *Atherurus macrourus* (Wilson and Reeder 1993). Untill now, the known distribution of the species was only Assam. Recently, one of us (M. Swamliana) sent a photograph of an animal taken at Hmuifang, Aizawl, Mizoram for identification to the BNHS; where it was identified as *Atherurus macrourus*. The occurrence of *A. macrourus* in the Aizawl district of Mizoram state is a new distribution record for the species which was so far known only from Assam. Interestingly, Mizoram and Myanmar share a common boundary.

The Bombay Natural History Society's collections has a male specimen (Reg. No. 8997) of this species collected at Tenasserim, Myanmar on 20.xii.1913.

According to Blanford (1891), this species was restricted to the east of Bay of Bengal. He further states, "the genus must have existed in the Indian Peninsula, for its teeth have been found in the Pleistocene cave-deposits of Kurnool".

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4. PREDATION ON CHITAL *AXIS AXIS* BY WILD PIG *SUS SCROFA* IN BANDHAVGARH NATIONAL PARK[1]

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On April 12, 2006, while we were at Bandhavgarh National Park to estimate Tiger population, we observed a group of six to seven Chital *Axis axis* grazing near a water hole at around 1700 hrs. A group of 12-13 Wild Pigs

Sus scrofa came near the same water hole. The sounder consisted of various age groups adult females, males and young ones. As the Pigs approached the Chital, one of the adult female Pig suddenly charged and caught an adult female Chital by her hind quarters. Two other adult Pigs joined in the attack and started eating the Chital that died after 15 minutes of the attack. The remaining Chital group gave warning calls, stood at some distance and watched.

Wild Pigs are omnivorous and are known to scavenge on kills made by large carnivores (Prater 1971: THE BOOK OF INDIAN ANIMALS, BNHS). They are likely to predate on young and helpless prey as well, but attacks on adult healthy large prey are rare. This observation shows that Wild Pigs are capable of bringing down large prey and can cooperate to improve hunting success.

5. COMMENTS ON – DEBARKING OF TEAK *TECTONA GRANDIS* LINN. F. BY GAUR *BOS GAURUS* H. SMITH DURING SUMMER IN A TROPICAL DRY DECIDUOUS HABITAT OF CENTRAL INDIA BY PASHA, M. K. S., G. ARINDRAN, K.P. SANKARAN, & Q. QURESHI, 2002: *JBNHS 99(2)*: 238-244[1]

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This article is based on an extensive research study done by the authors in Pench Tiger Reserve. The article, however, contains significant number of errors, which fall into three main categories.

Potentially misleading computations

The authors have used incorrect formulas to calculate areas of bark and debarked sampled teak trees (see p. 239). I fail to understand the author's logic of multiplying the area of a rectangle and/or square by a constant π to compute surface area of debarked portion. The calculations based on these formulas, obviously, have yielded bark and debarked areas 3.14 times than the actual areas. Thus, it is likely that proportions available to debark and utilized for debarking might give rise to spurious differences in GBH (girth at breast height) categories for preference and avoidance by Gaur (see Table 2). Consequently, it is possible that majority of preference ratings given in this table might be changed so as value of chi-square goodness of fit test (χ^2) given in the text (see p. 241). Further, the surface area of a cylinder is 2π x radius x height (where $\pi = 3.14$). Since radius of a cylinder is equal to its circumference upon 2π (Sharma and Trivedi 2002), therefore surface area of cylinder would be circumference x height, and not π x diameter x height as used in the analysis (see page 239).

The t values (debarked plots $t_{61} = 365.41$, $p < 0.0001$; un-debarked plot $t_{61} = 540.3$, $p < 0.0001$) on p. 241 appear to be very high. The t value at 61 degree of freedom should be between 3.4 and 3.5, which is statistically significant at 0.001 level of significance. I hope that t values given at new level of significance ($p < 0.0001$) in this article ought to be printing errors and not an expansion of the table of statistics by the authors.

The authors' present food habits of Gaur in Pench Tiger Reserve (see Table 1) as % observations (see column 3). The sum of values in this column works out to be 96.7% and not 100%.

Peer reviewing errors

Prima facie, the last line in the Introduction section (see p. 238) is inappropriate in its current position. It should have been in results as it projects field observations of the authors. At the best, this line should have been struck off, as it is re-mentioned in the discussion on p. 242. Further, Table 1 shows three grass species, whereas, in the text (results) the authors have claimed to record four grass species besides other plant biomorphs as summer food plants of the Gaur.

It is not clear anywhere in the article up to what age the authors have considered young Gaur as calves. Similarly, it is not understood from the perusal of the article as to what the authors mean by debarked and un-debarked plots (see Table 3). By debarked plots, do they mean sample plots that contained at least one tree debarked by Gaur? Also do un-debarked plots mean plots devoid of any debarked tree? Further, one fails to understand how the number of trees (931) in the available category (Table 2) exceeds actual sample size (630). Also, units of area have been left open to the reader's choice.

Significant amount of text in the article is irrelevant. For instance, "forest fire is known to affect the cambial tissue of trees ... No mortality of debarked tree was noticed as a result of low intensity forest fire" (see p. 242). How is such discussion relevant in the context of the present study, especially, when its basis does not find any place in the methods and results sections?

Doubtful results and discussion

This article claims that "among the plant parts eaten by Gaur, teak bark was the most frequent i.e. 14% (see p. 240). It, however, is evident from the data in Table 1 that teak bark was a supplementary for some and the main forage item by Gaur in Pench comprised of other plant parts (86%), specifically leaves (52.7%).

The authors suggest that teak bark was advantageous to Gaur over other plant parts as it has high mineral content (see Table 4, p. 242). However, no values for browsed parts of other plant species have been presented to support the argument. Further, they fail to enlighten the reader if mineral and protein contents in the barks of other available tree species were analysed, and whether they were found to contain lesser protein and other minerals than their corresponding values existed in teak bark. Further investigations can confirm if there are other reasons for the Gaur to consume teak bark.

The statement "it was easy for the gaur to strip the bark in large quantity and to reach the phloem and cambium layers that are rich in nutrients" (see p. 242) seems to be illogical. It gives an impression that Gaur also removes cortex, endodermis and phloem layers completely in order to reach the hard cambium layers, which are found between phloem and xylem tissues. For a layman who has some knowledge of dicotyledon's stem anatomy, bark is mainly composed of dead phloem cells and remnants (if any) of the peridermis.

6. A SIGHT RECORD OF MEW GULL *LARUS CANUS* IN GOA[1]

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The mouth of River Chapora at Morjim, Pernem, north Goa (15° 37' N; 73° 44' E) is a regular haunt for large numbers of gulls. Brown-headed Gulls *Larus brunnicephalus* usually form the bulk of the birds present, with variable numbers of up to six other species often being encountered.

As the leader of Sunbird Tours, I have visited Morjim about 30 times. During one such visit, on December 14, 1996, I found a first-winter Mew Gull *Larus canus* among the several thousand gulls that were roosting on the beach. The bird was watched for about 20 minutes, at ranges down to about 40 m by Paul Hyde, six other observers and me. We used a variety of optical equipment between us. I used a pair of 7 x 42 binoculars, and a telescope with magnification of up to almost 60x. Since many of the other observers and I lived in Britain, the Mew Gull was a species which we were very familiar with, and the bird presented no identification problems. Nevertheless, I recognized its local rarity, took some notes and made a hurried field sketch. I had previously seen one other Mew Gull in India, a second-winter bird with other gulls on the Ganges, at Garhmuktesar, Uttar Pradesh (28° 48' N; 78° 06' E) on March 05, 1993. This latter sighting has not been published other than as a brief report (Robson 1993).

Description

When perched, the bird appeared perhaps 5-10% larger than most of the neighbouring Brown-headed Gulls and noticeably bigger than all of the Black-headed Gulls *Larus ridibundus* present, yet was significantly smaller and more daintily proportioned than all the accompanying large gulls (both Heuglin's Gull *Larus heuglini* and Caspian Gull *Larus cachinnans*). Beside a more neatly rounded head and slimmer legs, the Mew Gull also had a proportionately shorter, neater bill, with a much reduced gonys, when compared with these larger birds.

The mantle, back, and most of the scapulars were a uniform blue-grey colour and were obviously darker and bluer in hue than the upperparts on all the small gulls present. Several of the bird's lower scapulars were still juvenile and retained the scaly, brownish, pale fringed appearance typical of that age.

The white forehead and loral area shaded into denser streaking over the crown and ear-coverts extends down onto the paler nape. There was a dark, almost blackish spot on the lores immediately in front of the eye, while the streaking on the lower hind neck swept around the front to form a weakly defined breast band of larger chevron-shaped scaling. The remainder of the bird's underparts were whitish, although the longer, lateral undertail coverts were also marked with conspicuous, rear pointing, brownish chevrons. Rump, uppertail coverts and most of the tail were also white, and there was a neat, and rather narrow, dark brown terminal tail band (the latter covered approximately one quarter of the tail's total length).

The folded wings were essentially brown, but on closer inspection, all of the smaller coverts were intricately

patterned, each with a darker brown shaft and pale fringe. There was a noticeably paler greater covert panel, the tertials were contrastingly dark brown and neatly fringed with white, this fringe being broadest around the tips of these feathers. The folded primaries were even darker brown than the tertials and appeared similar in shade to the tail band.

The legs were dull pink, as was the bill base. The distal third of the bill was neatly tipped black, and the eyes were dark.

The bird appeared indistinguishable from the nominate western *Larus canus canus*, which we see abundantly in Britain, but on range is most likely to have been the very similar *Larus canus heinei*. These two subspecies are not safely distinguishable in the field.

Status

This is perhaps only the fourth of the five sightings in India, and is currently probably the southernmost anywhere in Asia. Kazmierczak and van Perlo (2000) map four records for India, while Grimmett *et al.* (1998) map the three earliest sightings, and there is an additional, more recent record. In date order these are:-

A first-winter visitor on the River Yamuna at Okhla, Delhi (28° 34' N; 77° 17' E) on January 19, 1992 (Alström 1994).

A second-winter on the Ganges at Garhmuktesar, Uttar Pradesh (28° 48' N; 78° 06' E) on March 05, 1993 (Robson 1993).

A first-winter visitor seen by Per Underland at the Harike Lake Wildlife Sanctuary, Punjab (31° 10' N; 74° 57' E) on January 9-15, 1994 (Robson 1994).

The River Chapora at Morjim, Pernem, Goa (15° 37' N; 73° 44' E) on December 14, 1996.

An adult at Pong Wetland, Kangra district, Himachal Pradesh (32° 05' N; 76° 00' E) on February 06, 2004 (Jan Willem den Besten in litt. December 2004 Unpublished data).

Elsewhere in the region, the species is considered to be a vagrant to Nepal, where Inskipp and Inskipp (1985) list three records, all in January-February between 1979 and 1983. The Mew Gull is rare in Pakistan, where Roberts (1991) noted five records, involving six birds, including a probably exceptionally sighting as late in the season as April 04, 1984.

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7. WINTERING RANGE EXTENSION OF WHITE-THROATED BUSHCHAT *SAXICOLA INSIGNIS* GRAY IN INDIA[1]

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The wintering range of the globally Vulnerable White-throated Bushchat *Saxicola insignis* Gray in India was known to be from Haryana to Jalpaiguri, north West Bengal (Ali and Ripley 1987) before two records in Assam extended its wintering range further east to Manas National Park (26° 40'-50' N; 90° 50'-91° 25' E) (Narayan and Rosalind 1997), and later to Kaziranga National Park (26° 30'- 45' N; 93° 5'-40' E) (Sarma *et al.* 1997). Recent observation of this bird in eastern Assam has further extended its wintering eastern range to Dibru-Saikhowa National Park (27° 35'-50' N; 95° 10-40' E) and Merbil (27° 19' N; 95° 18' E) near Naharkatia. The White-throated Bushchat has also been observed in other areas of Assam other than these two places.

In the afternoon of January 25, 2004, a male was observed in Merbil near Naharkatia, foraging on an *Alpinia allughas* grove and calling "*tsek ... tsek ... tsek*". The bird was observed at about 4 m height from the water level.

A female bird was observed on the northern edge of Deepar Beel Bird Sanctuary (26° 05' N; 91° 40' E) on February 02, 2003 by the first author. It was foraging among short

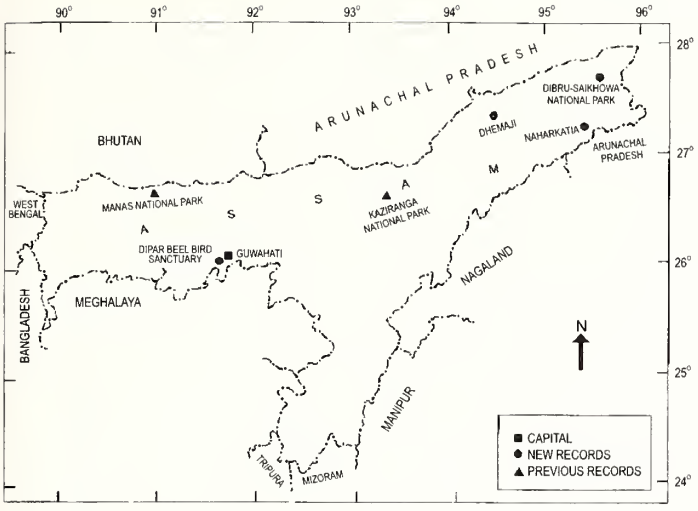

Fig. 1: Past and present wintering sites of White-throated Bushchat

grasses and ground close to the water. Later, on January 01, 2004, one male was observed in the same area. Again on January 01, 2005, one female was observed on an *Ipomoea aquatica* grove in the northern edge of the Sanctuary close to the Satmile.

On another occasion, a male was seen by the first author on February 10, 2004 near the Jia Dhal river (27° 25' N; 94° 30' E) close to National Highway 31 and 10 km west of Dhemaji town. The bird was perched on *Vetiveria zizanioides* grass. There were other short grasses and small scrubs in the area.

In Dibru-Saikhowa National Park, a lone male was observed foraging on April 04, 1997 at Kolomi grassland near Kolomi camp (27° 37' N; 95° 21' E). Then on March 01, 1999 two males were observed at Kundaghat area and a lone male was observed near Kolomi (27° 38' N; 95° 20' E) on April 15, 2000. The habitat of the area was Salix *Salix tetrasperma* swamp forest mixed with grassland. Later, on December 19 and 20, 2004 a female was observed at Toralimukh (27° 38' N; 95° 20' E) at about 1030 hours. All observations in the Dibru-Saikhowa National Park were made by the second author.

From these observations it is clear that the easternmost winter range of the White-throated Bushchat in India extends at least up to Dibru-Saikhowa National Park (Kolomi grassland 27° 37' N; 95° 21' E) and Merbil (27° 19' N; 95° 18' E) of Assam. Another important point is that a small population of *Saxicola insignis* regularly visits both Deepar Beel Bird Sanctuary and Dibru-Saikhowa National Park. However, there has been no recent report of this species in Manas and Kaziranga national parks after the sightings of Narayan and Rosalind (1997), and Sarma *et al.* (1997).

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8. FOREST WAGTAIL *DENDRONANTHUS INDICUS* IN JAMNAGAR MEDICAL CAMPUS[1]

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On February 23, 2005, at 1430 hours, we sighted a Forest Wagtail *Dendronanthus indicus* on a Neem tree in our hostel campus. We photographed the bird (Eds: photographic evidence provided) and observed it for the next three days at the same place.

Dendronanthus indicus is mostly recorded in evergreen and deciduous forests. In Gujarat, it is recorded in the Gir and Dang forest (Dharmakumarsinhji 1954, 1963). Himmatsinhji (1967, 1970) had seen this bird at Bhuj in his garden on January 10, 1967 and again at Vijayvilas, Mandvi on December 31, 1969. Khacher (1989) had seen it at Jasdan in his compound on November 19, 1967.

Our campus is in the middle of Jamnagar city, hence this sighting is worth recording.

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9. FURTHER RECORDS OF GREAT KNOT *CALIDRIS TENUIROSTRIS* AND RED KNOT *CALIDRIS CANUTUS* FROM THE NORTH-EAST COAST OF INDIA[1]

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In 2002-03, many interesting records of uncommon waterbird species were obtained from Chilika Lake (19° 28'-19° 54' N; 85° 05'-85° 38' E, Orissa, India) during our research project entitled "Habitat evaluation of Chilika Lake with special reference to birds as bio-indicators" involving bird-banding technique as one of the objectives to assess the population dynamics of waterbirds. On November 25, 2002, one Great Knot *Calidris tenuirostris* was trapped from the soggy land in Parikud area of the Lake. It was ringed, aged, measured, weighed and examined for moult before release. Interestingly, we recaptured the same bird exactly after 17 days from the same place. A few individuals were also sighted in 2004-05 season. These records helped to plug the gap in the status and distribution of this species in the Indian wintering grounds, especially along the east coast. As per the available records (Ali and Ripley 1983), the Great Knots migrate from their breeding grounds in Siberia to the Indian subcontinent during winter. This species is also recorded from Assam, Kolkata, Chennai, Andaman and Lakshadweep Islands (Ali and Ripley 1983). Until Balachandran (1997) reported the Great Knot as a regular winter visitor to the south-east coast of India, the status of this species was known as a rare winter visitor to the east coast of India, with a few stray records at Point Calimere (Ali and Hussain 1981) and Pulicat Lake (Mohapatra and Rao 1993). Recently, this species was found occurring regularly at Point Calimere as was evident from the number of birds ringed during the bird banding training programmes organized between 1999 and 2002 (Daniel and Balachandran 2002). A total of 250 individuals were sighted at Jumbodweep of Sunderbans during a field visit by us in October 2004, and 20 individuals were sighted from the same place during the first week of January 2005 by the Spoonbilled Sandpiper Expedition Team (Zöckler *et al.* 2005). A flock of 54 birds were seen by this team during the mid-winter Waterfowl Count-2005 carried out at Bhitarkanika. These records of this species at Chilika, Bhitarkanika and Sunderbans helped to establish this species as a regular, uncommon winter visitor to the entire eastern coast. Moreover, the record at Chilika Lake is the first record for this species.

Similarly, three individuals of the Red Knot *Calidris canutus* were caught at Nalabana Island on February 25, 2003. Recapture of one of the individuals after 16 days in the same area is interesting and worth mentioning. A total of twenty three and a single Red Knot were recorded during October 2004 and January 2005 respectively from Jumbodweep of Sunderbans. For the Red Knot, Balachandran (1990) and Rao and Mohapatra (1993) have revised the 'rare vagrant' status assigned by Ali and Ripley (1983) and Cramp and Simmons (1983) to a regular uncommon winter visitor to the south-east coast. Further extension of the wintering range up to Sunderbans was established through the ringing of Red Knots at Chilika and sighting at Sunderbans (Zöckler *et al.* 2005).

The measurements of Red Knots ringed at Chilika tallied with that of the measurements obtained for the subspecies *rogersi* reported by Balachandran (1998) in the south-east coast wintering ground of India. Though the sample size is small, it is helpful to predict that the subspecies found in the entire east coast may belong to *rogersi*, which breeds in east Siberia and winters in Australia.

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10. UNUSUAL OCCURRENCE OF FULVOUS WHISTLING-DUCK *DENDROCYGNA BICOLOR* (VIEILLOT 1816) AT CHILIKA LAKE[1]

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We were in the northern sector of the Chilika Lake in a motor boat from Kaluparaghat to Tinimuhani (Confluence point of three tributaries of the River Mahanathi, namely Daya, Bhargavi and Nuna), around 1130 hrs, when we saw a large congregation of birds in the open water. From a distance they looked like Gadwall *Anas strepera*. But, when we reached closer, we found that they were darker than the Gadwall and the twittering sound was diagnostic. They were brownish black and had a rusty-whitish collar around the foreneck like in the Fulvous Whistling-Duck *Dendrocygna bicolor*; I could confirm the identity from the white band formed by the upper tail coverts in flight. Meanwhile, our boatman moved the boat closer to the flock. This congregation consisted of *c.* 7,250 Fulvous Whistling-Duck. The unique composition without any other species was amazing to watch. I marked the exact geographical location of the area with the help of Global Positioning System (GPS) as 19.83° N; 85.47° E. Without disturbing the flock, we moved around the congregation and determined the water depth in three places. The depth varied between 30 and 40 cm. Further south-east we observed two more flocks of *c.* 1,500 and 4,600 individuals each at 19.83° N; 85.47° E and 19.83° N; 85.48° E respectively. These, however were mixed flocks; the other duck species in the flock were, Gadwall *Anas strepera*, Northern Pintail *Anas acuta*, Northern Shoveler *Anas clypeata*, and Tufted Duck *Aythya fuligula*.

Ali and Ripley (1983) mention the Fulvous Whistling-Duck as a resident and nomadic species which breeds in Bengal, usually less common than the Lesser Whistling-Duck *Dendrocygna javanica*, and occurs in smaller flocks. But the sighting of 7,250 birds in a single flock similar to other dabbling and diving ducks is a rare phenomenon for this species. However, such a congregation of the Fulvous Whistling-duck was never observed thereafter. Altogether the total number observed (14,490) was over 70% of its geographical population as per the estimates given by the Wetlands International (2002).

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I am grateful to Dr. S. Balachandran, Assistant Director, Bombay Natural History Society and the Principal Investigator of the project (Habitat evaluation of Chilika Lake with special reference to birds as bio-indicators) for his guidance and comments on this manuscript. I thank Mr. J.C. Daniel, Honorary Secretary for his comments on this manuscript. I am also thankful to the Chilika Development Authority, Govt. of Orissa, for funding this Project, and Chief Wildlife Warden of Orissa for granting necessary permission to the study. I greatly appreciate the hard work rendered by our field assistants Mr. P. Guruswamy and Mr. Niranjan Dalei.

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11. COMMENTS ON THE REVIEW BY ASAD RAHMANI, ON 'HANDBOOK ON INDIAN WETLAND BIRDS AND THEIR CONSERVATION'[1]

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While reviewing the 'handbook on indian wetland birds and their conservation' by Kumar *et al.* (2005), published by the Zoological Survey of India (ZSI), the reviewer commented, "unfortunately the ZSI is also famous for bringing out boring tomes, full of jargon and technical descriptions of new species which interest only the subject experts. This is now changing, thanks to the book brought out by Dr. Arun Kumar and his team" (Rahmani 2005).

According to the Oxford Advanced Learner's dictionary, the word 'tome' means a large heavy book, especially scholarly or serious one. A scholarly or serious book becomes boring only to the illiterate ignorant. Obviously, it is to the interest of subject experts only.

As rightly pointed out by the reviewer, the mandate of ZSI is to document the animal diversity of the country. In the Convention on Biodiversity of 1992, and later in several new global agreements, the message of conservation and sustainable use of biodiversity has been on the prime agenda. The sole reference system for biodiversity interpretation is catered by the science of Taxonomy (Narendran 2006). Faunal documentation, including describing new species, as practiced by ZSI has to follow the principles of taxonomy using the technical or specialized words particular to that branch of science. Every branch of science uses its own recognized terminologies, however difficult it may be for others to understand.

If the taxonomic descriptions are boring to the reviewer, being the Executive Editor of the *Journal of the Bombay Natural History Society*, why the reviewer provides a section called New Descriptions in his *Journal* that uses only the taxonomic jargon? Obviously, it is to the interest of subject experts only.

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The author is grateful to the Director, Zoological Survey of India, Kolkata, for facilities and encouragement.

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12. FOOD AND FEEDING HABITS OF THE GREEN TURTLE *CHELONIA MYDAS* IN RELATION TO MARINE PLANTS IN THE GULF OF MANNAR BIOSPHERE RESERVE, INDIA[1]

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Introduction

Green turtles are the most abundant sea turtles in the Gulf of Mannar and Palk Bay (Deraniyagala 1939; Kuriyan 1950; Carr 1953; Jones and Fernando 1968; Agastheesapillai and Thiagarajan 1979; Bhupathy and Saravanan 2001), they are primarily herbivores, feeding on a variety of marine algae

and sea grasses in selected grazing areas (Russel and Balazs 2000). Young Green Turtles are believed to occupy open ocean pelagic habitats, perhaps in association with sargassum rafts in some areas, after leaving the nesting beach (Walker 1994). They are omnivorous with a strong tendency to carnivore during this life stage (Bjorndal 1985). Green Turtles leave pelagic habitats and enter benthic foraging areas at a size of 20 to 25 cm carapace length, at this time they shift to herbivorous diet (Bjorndal and Bolten 1988; Limpus *et al.* 1994). Studies are available on the diet of Green Turtles in Oman (Diez and Dam 1992). In Australia, feeding of Green Turtles was discussed by Limpus *et al.* (1994). Records of the diet of Green Turtles are available from a number of locations in the Pacific (Kurata *et al.* 1978). In the Caribbean, the sea grass is the primary diet species for the Green Turtle (Bjorndal 1982). About 271 genera and 1,153 species of marine algae belonging to four groups of algae namely Chlorophyceae, Rhodophyceae, Phaeophyceae and Cyanophyceae have been recorded so far from Indian waters. The standing crops of sea weeds from intertidal and shallow waters of all maritime states and Lakshadweep was estimated as 91,339 tonnes wet weight (Kaliaperumal and Kalimuthu 1997).This note provides information on the diet of Green Turtles as well as the present status of marine plants in the Gulf of Mannar area.

Study Area

The Gulf of Mannar extended from Cape Comorin (8° 4' 40" N; 77° 33' 4" E) to Dhanushkodi (9° 9' 9" N; 79° 26' 46" E) and has about 250 km of coastline. Extensive coral reefs and patch reefs rise from shallow areas of the seashore. Fringing reefs are located mostly at a distance of 50-100 m, from the Islands and are narrow. The Gulf of Mannar Marine Biosphere Reserve is India's first Marine National Park. The luxuriant growth of several species of green, brown and red algae occur in the Gulf of Mannar. There are 147 species of seaweeds and 52 species of sea grass recorded in this area. The area between Rameswaram and Kanyakumari provides 75,372 tonnes (wet wt) of seaweeds in an area of 1,863 sq. km (Kaliaperumal and Kalimuthu 1997).

Samples were collected from the incidentally caught Green Turtles during fishing operations. These turtles had died due to incidental catch, forced submergence in fishing nets, being hit by boats and simultaneously washed ashore. Their carcasses were salvaged for research purpose. Observations on stomach contents were made during April and May 2004 near CMFRI Jetty and Dhanushkodi along the Gulf of Mannar Biosphere Reserve. The stomach contents of six Green Turtles (2 male, 3 females, and 1 subadult) were collected. The morphometric measurements such as curved carapace length and width, and plastron length and width were also collected, as suggested by Bolten (1999).

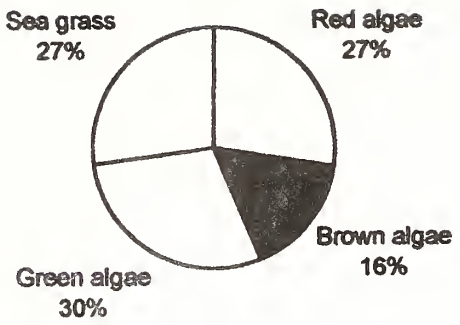

Fig. 1: Volumes of marine plants recorded in the stomach of green turtle *Chelonia mydas* at Gulf of Mannar

Partially digested seaweeds and sea grasses were noticed in the digestive tract and gut of six individuals of green turtles. Algae are characterized according to their general colours: 27% of red algae (Rhodophyta), 30% green algae (Chlorophyta), 16% brown algae (Phaeophyta) and 27% sea grasses. A qualitative list of the component present in the diet sample was prepared. The mean weight of the food items of the six turtles was as follows, *Gelidiella acerosa* 200 gm, *Hypnea valentiae* 37 gm, *Solieria robusta* 60 gm, *Sargassum* spp. 38 gm, *Pocockiella variegata* 66 gm, *Dictyota dichotoma* 100 gm, *Halimeda macroloba* 112 gm, *Caulerpa fergusonii* 58 gm, *Ulva reticulata* 29 gm and sea grasses, such as *Halophila ovalis* 192 gm, *Thalassia hemprichii* 205 gm and *Cymodocea serrulata* 89 gm. The curved carapace length of Green Turtle ranged from 50-104 cm and weight from 20-65 kg.

Discussion

By knowing the food and feeding of green turtle, one can understand the feeding ecology and physiology of the turtle. Data obtained from such studies can provide insight in to questions relating to habitat utilization, digestive physiology, estimation of diet contaminations, trophic ecology, endoparasitic load and health of the individuals (Forbes and Limpus 1993). Differences in diet either in quality or quantity is believed to cause the difference in mean growth rates of Green Turtles from different foraging areas (Balazs 1983). An herbivorous diet has important consequences for life history parameters and survival outlook of Green Turtles and it has major effects on the nutrient cycling and community structure in their foraging habitats (Bjorndal 1985). Russell and Balazs (2000) reported that the Green Turtles feed mostly on marine algae in selected grazing grounds. Stomach samples taken from Hawaiian green turtles had 275 species of green

algae, brown algae, red algae, blue green algae and sea grasses (Russell and Balazs 2000). Studies made by Balazs (1985), Balazs *et al.* (1987), Russell and Balazs (1994) provided information on list of seaweed species found in the stomach of Green Turtles. Based on the study of Forbes and Limpus (1993), the diet of 518 green turtles feeding on the reef surrounding Heron Island, Australia, was composed of 38 species of red algae, 21 species of green algae and 10 species of brown algae. The digestive tract of seven Green Turtles captured off the coast of Colima and Jalisco, Mexico contained green and red algae (Fritts 1981).

Studies by Agastheesapillai and Thiagarajan (1979) reveal the occurrence of several species of seaweeds in the stomach contents of Green Turtles collected from Kilakarai and Vedalai areas in the Gulf of Mannar. Fifteen species of seaweeds and sea grasses recorded from the stomach contents of Green Turtles showed the preference of these species. When compared with the earlier studies, the present study confirms the earlier observations that the seaweeds and sea grasses are the major food for the endangered green turtle *Chelonia mydas*. Sea weeds are exploited for commercial purposes only from southeast coast of India, especially from Vedaranyam to Kanyakumari coast, which resulted in the depletion of standing crops and species diversity (Kaladharana and Reeta 2003). Despite rich resources of the sea weeds, the exploitation is not uniform in many areas; overexploitation is actually felt in the Gulf of Mannar, southeast coast of India. Effective conservation measures should be mandatory for the conservation of marine plants and green turtle..

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13. FIRST RECORD OF SLENDER RACER *COLUBER GRACILIS* (GÜNTHER, 1862) (SERPENTES: COLUBRIDAE) FROM RAJASTHAN[1]

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On December 22, 2004 in Nal Sandol Reserve Forest, near Dimri village, Jhadol tehsil, Udaipur district (24° 20' 37.74" N; 73° 29' 55.64" E; 690 m above msl), we came across a snake about 750 mm long that had been injured by labourers. It was slender bodied, and had two pale brown, black edged, forward-pointing V-shaped marks on top of the head followed by white coloured black-edged cross bars, which widen on the sides to join with adjacent bands. Towards the hind body, the bands were replaced by narrow, sometimes broken blackish cross lines. The belly scales were glossy white. The snake was identified as the Slender Racer *Coluber gracilis* based on its scalation: midbody scales in 21 rows; ventrals 217; subcaudals 131, paired; anal divided; preoculars 2, of unequal size; postoculars 2; temporals 2+2; supralabials 9 (5th and 6th touching eye). A black stripe was present below each eye at the meeting line of 6th and 7th supralabials. Subcaudals were more than recorded (118-127) by Whitaker and Captain (2004).

The specimen was deposited in the Department of Zoology, Mohanlal Sukhadia University, Udaipur, Rajasthan.

The snake was seen in a hilly, highly degraded deciduous forest, with a network of dry nullahs. *Anogeissus latifolia*, *Madhuca latifolia*, *Feronia limonia* and *Butea monosperma* grow on the slopes and at the foothills. *Sterculia urens*, *Lannea coromandelica* and *Ficus arnottiana* are present higher up on the hills. Thickets of *Lantana camara* are also present randomly. The grass *Aristida adscensionis* is common owing to degradation, but patches of *Themeda quadrivalvis*, *Apluda mutica* and *Heteropogon contortus* are also seen.

Coluber gracilis is endemic to India. Presently, this species has been recorded from a few localities in India: Pune district, Nane Ghat and Phaltan all in Maharashtra, and Asirgarh, Madhya Pradesh (Whitaker and Captain 2004). Literature scanning reveals that *C. gracilis* is a new record for Rajasthan (McCann 1946; Sharma 1999, 2001; Sharma *et al.* 2001; Sharma *et al.* 2002). The presence of *C. gracilis* in southern Aravallis in Rajasthan is interesting and worth mentioning.

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14. POSSIBLITY OF BREEDING GROUNDS OF MAHSEER IN THE PAISUNI R. (CHITRAKOOT DHAM), ITS ECOLOGY, AND STATUS OF *TOR TOR* (HAMILTON) IN THE NORTH VINDHYAN RIVERS[1]

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The genus *Tor*, known as Mahseer, is widespread from Afghanistan in the west through India, Pakistan, Nepal, Bhutan to Southern Asia (Thailand and Malaysia) in the east, and is also present in China. All the Mahseers are presently

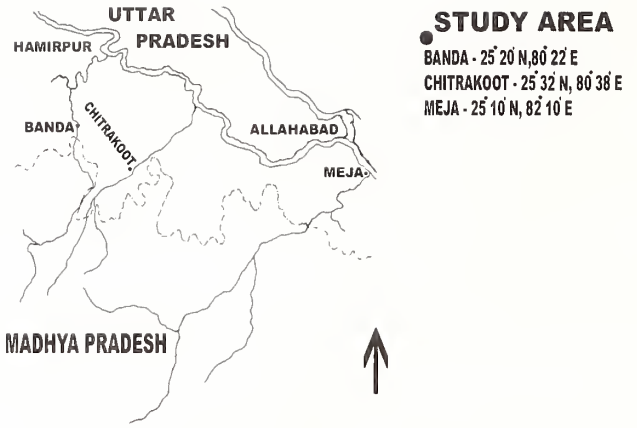

Fig. 1: Rivers draining from north Vindhyan region

classified as endangered/threatened species (Sinha 1992, 1994), and have spectacular sporting qualities and table value. Desai (2003) has described 10 valid species of Mahseer. Khan and Sinha (2000) are of the opinion that the distribution of Mahseer is governed by temperature (6-30 °C) as it influences the rate of development and growth, duration of the life history stages, longevity as well as the size and form of individual. This is a broad generalization. Taking common occurrence as a criterion, each species is distributed in a specific river system; *Tor putitora* and *T. progenius* are common in the Ganga and Brahamputra river systems along the Himalaya, *T. mosal* along eastern India (Mahanadi river system), *T. tor* in central India (Narmada), and *T. khudree* and *T. mussullah* in the Deccan (Cauvery, Godavari, Krishna).

Considerable information has been generated on *T. putitora* and *T. tor* over the last few decades, especially from the Sutlej (Johal and Tandon 1981; Johal *et al.* 1999), and the Ganga river system in the Himalaya, north-west India (Nautiyal 1994; Bhatt *et al.* 2000) in case of *T. putitora*, and from the Narmada in case of *Tor tor* (Desai 2003). The deep-bodied *Tor tor* is present in the rivers and reservoirs north of the Narmada-Paisuni (Grover and Gupta 1977), Ken

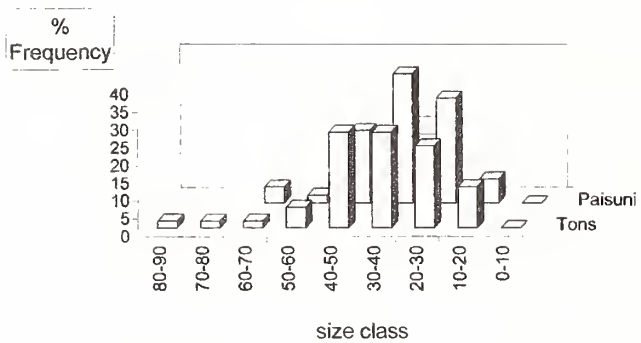

Fig. 2: Size composition (as %) of *Tor tor* in the Vindhya rivers, Tons and Paisuni. 20-50 cm size was prevalent in these rivers

(Srivastava *et al.* 1970), and the Gandhi Sagar Reservoir in Madhya Pradesh (Anon. 1968).

There is no information on its breeding grounds in north Vindhya rivers. Hence, it was considered appropriate to generate some information on the population dynamics of *T. tor* from rivers draining the north Vindhyan region (Fig. 1). These rivers arise in the hills north of Narmada, and drain into the Yamuna, and its principal tributary the Chambal. Though devoid of high mountains, the elevated plateau does provide a gentle gradient and the rocks a stony substratum, a favourite haunt of Mahseers. Paisuni is a 100 km long river, draining the northern extremity of the Vindhya flowing through forests in the upper stretch and cultivated land in the lower stretch. In the upper stretch it is 10-20 m wide, the bed is rocky and depth varies from 1-2 m, and the water is clear, indicating the oligotrophic nature of the river. The macrophytic vegetation also occurs along banks or in patches. Epilithic algae (1543 cells per sq. cm) were represented by species of *Achnanthes* (over 50%) and *Cymbella*. The bottom fauna of the upper stretch (355 individuals per sq. km) comprised nymph of Ephemeroptera, larvae of Diptera and Trichoptera. Oligocheate-annelids and molluscs, primarily the gastropods, were rare. The physical quality during December (2003) was as follows, water temperature (16.5-21.5 °C), air temperature (11.0-21.5 °C), current velocity (1.0-30.94 cm per/s), pH (7.0-8.0), discharge 1.10 cusecs. The organisms found in the Paisuni indicate pristine nature of the water attributed to religious protection by virtue of its pilgrimage status (Chitrakoot Dham) and Reserved Forest (Madhya Pradesh).

Preliminary studies on the size composition indicated that fish measuring 18-82 cm and 18-65.3 cm were found in the Tons and Paisuni, respectively. In the Tons, 76.9% of the population was constituted by fishes measuring 20-50 cm, while in the Paisuni 86.4% comprised this size range. The size classes 30-40 and 40-50 cm were dominant in the Tons while only 30-40 cm in the Paisuni (Fig. 2). It is obvious that Tons had better size composition, but Paisuni had a good share of brooders (36.4%), even the previous size class 20-30 cm was quite good (29.5%) compared with 26.9% in each of the size group of Tons sample. This can be attributed to the religious sanctuary provided by the temples along the river at Chitrakoot Dham. Fishing is prohibited. Since the Mahseer are known to exhibit rheotropism (tendency of upstream migration, Nautiyal 2002) for breeding, this protected stretch of the river (upstream of Chitrakoot Dham, the Ramghat, Kanch Ka Mandir, Sphatic Shila and Sati Ansuiya are temple destinations), and its upstream section can be the only possible breeding grounds in the Paisuni. As such fishing and unwanted human activities are prohibited for a considerable stretch, and

it seems to be an ideal place for the fish to breed.

However, observation during the first monsoon showers revealed that the fish which is a common sight on flour baiting, especially at Sati Ansuiya, was not sighted even once after an hour long baiting schedule. This suggests that in the Paisuni river the fish probably breeds upstream of Sati Ansuiya; this is a densely forested area lacking habitation. Since it is not accessible, it serves as a perfect sanctuary with undisturbed breeding grounds for *T. tor*, in particular, and fish assemblages in general. Also the origin of the river is quite near. The Tons on the other hand has habitation all along its course, and therefore the fish population is relatively low. Also breeding grounds, which must be in the upper reaches, suffer from acute human interference (agriculture). Studies on population structure are in progress to understand how exploitation affects age distribution and ecological health.

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15. ON THE RECORD OF *GARRA CEYLONENSIS* BLEEKER 1863: A SRI LANKAN CYPRINID FISH FROM INDIA[1]

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Introduction

Twenty four fish species under genus *Garra* have been reported so far from the Indian subcontinent (Jayaram 1999), of which nineteen species are found in India. Several new species and new records of the fishes under this genus have been reported in the past two decades. Remadevi and Indra (1984) described *Garra menoni* from the Silent valley, Kerala, India; Vishwanath and Sarojnalini (1988) discovered *Garra manipurensis* from Manipur; *Garra kalakadensis* was discovered from the Kalakad Wildlife Sanctuary, Tamil Nadu (Remadevi and Indra 1992); *Garra surendranathani* from the Chalakkudy river of Kerala (Shaji *et al.* 1996) and *Garra*

periyarensis by Gopi (2001) from Periyar. However, so far, there is no report of the Sri Lankan species, *Garra ceylonensis* from Indian waters. During the species inventory surveys conducted in the rivers of Kerala, as part of the NAT-ICAR project on 'germplasm inventory, evaluation and gene banking of freshwater fishes', the authors collected eight specimens of *Garra ceylonensis* (Bleeker 1863) from the Pooyamkutty tributary of River Periyar.

The specimens were collected using a cast net of 12 mm mesh size, and gillnet of 32 mm mesh size from Pooyamkutty. Morphometric measurements were recorded with a dial reading calliper with an accuracy of 0.1 mm. This data has been presented as percentages, with the range followed by the mean in parentheses. Meristics were counted following Talwar and Jhingran (1991). Revisionary work on the fishes of genus *Garra* by Menon (1964) was also consulted.

Description: Based on 8 specimens collected from Pooyamkutty, Periyar river, ranging from 101.04 mm-121.4 mm SL.

D.II 8; P.12-13; V.I 7; A.I 5; C.17

Body elongate and slender. Depth of body 16.38-21.26% in SL (19.12%), mental disc well developed, length of the disc 98.41-99.79% (99.1%) in its own width and the latter 41.4-49.08% (44.24%) in the width of head. Snout pointing, tip marked by a transverse groove, horny tubercles on snout and sides in front of nostrils. Barbels two airs, rostral barbels equal to or greater than diameter of eye. Eyes moderately large, not visible from ventral side of head, diameter 15.61-20.08% (17.60% of head length, 39.33-48.07% (45.52%) in interorbital distance. Interorbital distance slightly concave and is 32-41.78% (36.21%) in length of the head. Scales moderate sized. Distance of the vent from anal fin origin 35.9-38.21% (37.03%) in that between anterior origins of ventral fin and anal fin. Caudal peduncle length 11.52-14.86% (12.72%) in SL, 39.4-43.31% (41.85%) in head length and its least depth 84.78-95.74% (90.69%) in its own length.

Squamation: 34-35 scales along lateral line, 4-4.5 from origin of dorsal to lateral line, 3.5 between lateral line and pelvic fin origin, predorsal scales 11-23, prevental scales 13 and preanal scales 26, circumpeduncular scales 12. Breast and belly scaled.

Fins: Dorsal fin inserted closer to snout than to caudal. It is equal to head length. Pectorals slightly smaller than head and form 78.03-88.08% (83.86%) in it. Ventral fins smaller than head, and form 74.19-93.72% (81.73%) in it and in pectoral fin length. Distance between pectoral and ventral is 26.22-31.88% (30.12%) in SL. Distance between ventral and anal fins 24.24-26.56% (25.63%) in SL. Caudal forked.

Coloration: In life, olive green on the back and dull white underneath. A dark brownish black lateral band from the snout through eyes extending to caudal fin rays. This is bordered above and below by narrow yellowish stripes. Very light dark stripes are also seen on either side of the yellow bands which sometimes appear as small spots arranged in series. A black spot at the upper angle of gill opening present. Fins generally yellowish with rays have red orange tinge on their bases.

Distribution: Sri Lanka, India: Kerala, Periyar river.

Remarks: According to Menon (1964), *Garra ceylonensis* (Bleeker 1863) is closely related to *Garra mullya* in body stature and to some extent in its colour pattern, but strongly differs in interorbital width to head length ratio — 2 or less than 2 times in head length in *Garra mullya*, but greater than 2 times than *Garra ceylonensis*. Also, the width of suctorial disc to head width ratio is lesser in *Garra ceylonensis* as compared to *Garra mullya*.

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16. RANGE EXTENSION OF *SALMOSTOMA SARDINELLA* (OSTEICHTHYES: CYPRINIDAE) TO STREAMS OF TAMIL NADU, KERALA AND KARNATAKA PART OF WESTERN GHATS[1]

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Valenciennes (1842) described *Salmostoma sardinella* from Myanmar. Day (1875-1878) recorded it from the Irrawadi river at Myanmar. Talwar and Jhingran (1991) reported its distribution in Ganges, Brahmaputra drainage, and Orissa. Distribution of this species was from West Bengal (Ganges river system), Assam (Brahmaputra river system), Orissa (Mahanadi river basin) and from Bangladesh, Myanmar, Pegu and Moulmein Myanmar (Jayaram 1999; Menon 1999). Recently, it has been recorded from Mondai stream in Maharashtra (Arunachalam *et al.* 1999). The present record of the species is from Manjal stream (11° 42' 8.7" N; 76° 22' 4.6" E) in Muthanga (Wynaad) Wildlife Sanctuary, Sivasamudram (near Ganganachukki bluff in Karnataka (12° 14.5' N; 77° 9' E) Pillur dam and Moyar river (Gugalthurai 10° 45' N; 76° 53' E) in Tamil Nadu.

Description

D iii 7; A iii 17-18; P 12; V i 7

Body elongated and compressed; depth 4.25 to 4.5 times in standard length; dorsal profile equally convex as ventral profile. Abdomen keeled from below pectoral fin to vent. Head small, its length 3.9 to 5.3 in SL. Mouth supraterminal, oblique; lower jaw with a rudimentary symphysial process. Gill rakers 15 to 18 on first arch. Dorsal fin inserted just opposite to the origin of anal fin. Scale medium; lateral line with 48-51 scales; lateral transverse scale rows; 7 rows of scales between lateral line and dorsal fin base, and 2 rows of scales between lateral line and pelvic fin base; predorsal scales 27. Morphometric characters of the specimens examined are given in Table 1.

Colour: In life, dorsa greyish-green, flanks silvery and

Table 1: Morphometric measurements of *Salmostoma sardinella* in four streams in the Cauvery river basin

Proportion	Manjal N=1	Pillur N=2		Sivasamudram N=1	Gugalthurai N=1
		Range	Mean		
Total length (mm)	99	141-143	142	72	86
Standard length/Head length	5.31	4.96-5.08	5.02	5.42	4.60
Standard length/Body depth	5.89	4.70-4.91	4.80	6.12	4.83
Standard length/Predorsal length	1.61	1.48-1.53	1.50	1.54	1.55
Standard length/Post dorsal length	3.12	3.07-3.25	3.16	2.74	3.09
Standard length/Pectoral fin	3.86	4.07-4.07	4.07	4.18	3.71
Standard length/Pelvic fin	7.22	7.52-7.54	7.53	7.48	-
Standard length/Caudal fin	5.18	4.5-6.05	5.27	5.00	4.05
Standard length/Prepelvic	2.12	1.98-2.12	2.05	2.14	-
Head length/Eye diameter	2.06	3.51-3.58	3.54	2.88	2.72
Head length/Innerorbit width	2.05	5.71-6.49	6.10	7.85	6.74
Head length/Snout length	7.97	1.76-1.98	1.86	2.17	1.71
Head length/Pectoral fin	0.72	0.80-0.82	0.81	0.77	0.80
Head length/Pelvic fin	1.36	1.48-1.51	1.49	1.38	-
Length of caudal peduncle/Height of caudal peduncle	3.20	4.20-4.50	4.30	4.50	4.72
Pelvic to Anal fin/Pectoral to Pelvic fin	0.72	0.70-0.84	0.77	0.71	-

fins yellow. After preservation, dorsa pale brown, flank pale yellow, and fins remain yellow.

Distribution: Irravadi river (Myanmar); Poonpun river, Patna, Ganga, Brahmaputra drainage, Mahanadi river (Menon 1999), Mondai stream in Maharashtra (Arunachalam *et al.* 1999), Manjal stream in Kerala; (Gaganachukki bluff) Sivasamudram (Gaganachukki bluff) in Karnataka, Bhavani (Pillur) and Moyar rivers in Tamil Nadu.

Remarks: *Salmostoma sardinella* prefers closed riparian cover except in Sivasamudram Falls; the habitat parameters are given in Table 2. Though the extension range covers Tamil Nadu, Kerala and Karnataka parts of the Western Ghats, the distribution of *Salmostoma sardinella* is still confined to the tributaries of Cauvery basin originating from these three states.

Table 2: Habitat features of four streams

Parameters	Manjal	Sivasumdram	Gugalthurai (Moyar)	Pillur (Bhavani)
Riparian cover (%)	60	Open	30	41.5
Mean with (m)	9.8	200	19.4	63.46
Depth (cm)	56.5	130	54.6	62
Flow (m/sec.)	0.22	0.64	0.06	0.44
Bedrock (%)	15	90	20	10
Boulders (%)	45	5	60	5
Cobbles (%)	12.5	5	10	10
Gravel (%)	22.5	-	6	-
Sand (%)	2.5	-	4	72.5
Leaf litter (%)	2.5	-	-	2.5

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17. ON A RECORD OF A YOUNG TERATOID *CARCHARHINUS HEMIODON*[1]

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The 'vulnerable' *Carcharhinus hemiodon* (Compagno *et al.* 2003) is one of the 30 species of Family Carcharhinidae (Class: Elasmobranchii, Order: Carcharhiniformes). Commonly called the Pondicherry Shark, and locally 'Palsura', it is distributed in the Indo-West Pacific: Gulf of Oman to Pakistan, India, Sri Lanka and scattered localities in the eastern Indian Ocean and western Pacific Ocean. It attains a maximum size of up to 200 cm total length, and is viviparous and harmless. Carnivorous in nature it preferably feeds on small fishes, crustaceans and cephalopods (Compagno and Niem 1998). It fetches high commercial and market value due to its tasty flesh and oil content.

C. hemiodon (length 1.45 m and weight 3.5 kg) was caught during September 2004 using trawl net from the coastal

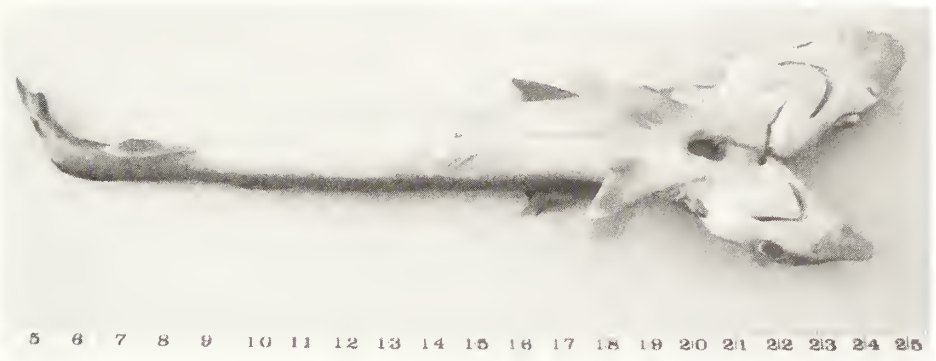

Fig.1: *C. hemiodon* ventral side

region of Kanyakumari region (Tamil Nadu, India). When the fish was dissected for research purpose we found four young ones inside the uterus, along with placenta. Among the four young ones, three were normal (length 25-27 cm and weight 150-200 gm), and one was abnormal, with two heads (bifurcated head) and a single body. The total length of the teratoid individual was 20.6 cm on the right side and 20.0 cm on the left side of the head regions and weight was 104.3 gm. Morphologically when the neural fold deviated during the early development it formed two heads with a single body (Fig. 1). The deformed individual had a separate placenta connected to the uterus. There was no morphometric and meristic difference between the normal and abnormal individual except the teratoid trait. The right and left head measurements were 5.5 cm and 4.8 cm respectively. It was observed that it possessed only one pair of pectoral fins (one behind each head), on the ventral side, and two dorsal fins (one behind each head) instead of a single dorsal fin. This abnormal individual showed an underdeveloped snout and mouthparts on one head (left head) while the other head, had its mouthparts normally developed. Since the specimen was rare it was not dissected for further study and was preserved in 4% formalin, and kept in our department museum.

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18. NOTES ON THE BEHAVIOUR OF SOME DUNG BEETLES IN AND AROUND BANGALORE[1]

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On the basis of dung utilization behaviour Heinrich and Bartholomew (1979) classify Coprophagous beetles into three groups: (i) those that feed and breed in dung pats (endocoprids) (ii) those that tunnel into soil, pack dung to subsequently feed and breed in it (paracoprids) and (iii) those that roll dung away from the dung pat which is further used for both feeding as well as breeding (telecoprids). Hitherto unknown details of dung utilization in two dung buriers, namely *Heliocopris bucephalus* (Fabricius) and *Onthophagus duporti* Boucomont, as well astwo dung rollers, namely *Scarabaeus* (*Khepher*) *sanctus* (Fabricius) and *Sisyphus hirtus* Weidemann, are detailed below.

Table 1: Duration and dimensions of the immature stages of *Onthophagus duporti*

Developmental time (days)	Egg		Larva		Pupa	Total	
All individuals	3.48±0.48 n=20		12.59±1.23 n=15		4.36±1.48 n=15	20.48±1.65 n=9	
Dimensions (mm)	Egg stage I	Egg stage II	I instar	III instar	Pupa	Cocoon	Brood ball
All individuals*	L-2.4±0.1 n=15 B-1.0±0 n=15	L-2.5±0 n=7 B-1.5±0 n=7	6.0±0.9 n=15	13.1±1.5 n=18	L-7.7±0.9 n=14 B-4.7±0.3 n=14	L-9.1±0.6 n=16 B-7.2±0.7 n=16	L-23.0±2.1 n=2 B-14.2±5.3 n=12

*L = Length, B = Breadth

Onthophagus duporti

Adults are found throughout the year. They are the most abundant Scarabaeinae in dung pats and are found in greater numbers along the margins of dung pats and in the rhizosphere. As many as 255 adults were found in a single cow dung pat in November.

This species nests at depths of 8-10 cm by fashioning several cylindrical brood masses in each of which a single egg is laid. The eggs are cream to yellow, cylindrical and fixed by the pointed end to the egg cell. The eggs increase in size and change to spheroids towards completion of the incubation period (Table 1). On hatching, the larvae not only resemble but also behave and nest in a manner identical to *O. gazella* and *O. rectecornutus* (Veenakumari and Veeresh 1996). As *Onthophagus* is a very large genus similar observations have been made on other species in the genus (Horgan 2001; Hunter *et al.* 1996; Lee and Peng 1982).

The durations taken for completing different developmental stages and measurements of these stages, including cocoon and brood mass, are presented in Table 1.

***Heliocopris bucephalus* (Fabricius)**

Both cow and elephant droppings attract adults of *H. bucephalus*. They make shallow food burrows and provision with less dung when compared to brood burrows which are much deeper and provisioned with larger quantities of dung (2,029 g). After excavating dung pats the beetles dig and excavate soil with their clypeus and forelegs to construct food and brood burrows. Males and females dig independent food burrows and provision them with food. Burrows from which food is exhausted are abandoned and fresh burrows constructed and provisioned with food. On the other hand brood burrows were constructed collectively by both males and females. A large amount of soil (1,014 g ± 36.32, n=3) was also excavated while constructing these brood burrows. Bisexual cooperation was exhibited by these beetles, similar to that in *H. dilloni* (Kingston and Coe 1977). The male was found in the upper part of the tunnel while the female was confined to the lower part of the tunnel. The tunnel was straight with no deviations for a distance of 20 cm after which it was oblique, ending in a chamber. The brood burrows were deeper than the food burrows. Kingston and Coe (1977) worked on the nesting behaviour of *H. dilloni* in Kenya and suggested that the brood chamber's depth varied to avoid both extreme climatic conditions as well as predators. Two to three adults of the kleptoparasite *Onthophagus turbagus* Walker were found in half a dozen brood balls. The different brood chamber parameters are mentioned in the Table 2.

When disturbed, the adults produced a loud, screeching noise by rubbing their hind coxae against their abdomens,

Table 2:Brood ball and burrow dimensions of some dung beetles

	Scarabaeus sanctus	*Sisyphus hirtus*	*Heliocopris bucephalus*
Diameter of dung ball (cm)	4.09±1.23 n=5	0.95±0.15 n=7	-
Weight of the food ball/mass (g)	45.23±22.94 n=5	0.136±0.006 n=7	186.5±18.45 n=3
Dry weight of soil excavated (g)	79.9 n=1	-	1014±36.32 n=3
Time taken to bury a dung ball (minutes)	25 n=1	-	-
Depth of brood cell (cm)	16±1 n=3	-	90
Weight of the brood ball/mass (g)	105 n=1	-	2029
Diameter of food burrow entrance (cm)	-	-	4.9±0.22 n=4
Depth of food burrow (cm)			28±12.88 n=5

which is probably an anti-predator mechanism (Arrow 1931; Narendran and Joseph 1978).

***Scarabaeus* (*Khepher*) *sanctus* (Fabricius)**

Adults of *S.* (*K.*) *sanctus* emerged from the soil in June-July with the first monsoon showers. Guided by olfaction they flew and dropped a short distance from either sheep or cow dung. Walking up to the dung with raised antennae each beetle cut out a circular mass of dung using its clypeus and forelegs, and fashioned a spheroid. Once fashioned, the ball was rolled away from the dung pat in the direction of the wind by pushing with the forelegs while the beetle walked behind the ball on its hind legs. In 1963, Matthews divided the whole process of ball making into different phases, namely 'cutting phase', 'shaping phase', 'rolling phase' and 'burying phase'. While rolling, the beetle paused repeatedly to shape the ball and to inspect the soil to find a suitable spot for burying it. Having dug deep the beetle emerged from the pit, pushed the ball in and disappeared beneath the ball to continue digging and slowly sank the ball into the soil. In one instance it took 25 minutes for a beetle to bury a brood ball and in the process 79.9 g of soil was excavated. The dimensions of brood balls are mentioned in Table 2. When these beetles were disturbed they produced a screeching noise.

The presence of small soil mounds indicated the presence of these beetles in the soil. On removing such mounds a hole marking the entrance to a tunnel was seen. Tracing this revealed mating pairs of beetles along with dung masses. In some instances, additional males were present nearby indicating male competition for a mate. Males were also noticed to fight each other for possession of dung balls right from ball making to rolling, which continued even after burying. This resulted in dung balls being abandoned near dung pats. Legs, elytra and other body parts lost in such battles were found in the vicinity of these dung balls, which once abandoned were utilized by dipterans and by *Onthophagus ramosus* (Weidemann). Similar combats have been reported for *Scarabaeus*, *Gymnopleurus* and *Sisyphus* (Halffter and Matthews 1966). In 50 per cent of the instances observed individuals of *Onthophagus* sp. were found in the dung balls fashioned for food by *S. sanctus*, indicating intraspecific competition for food.

Bisexual cooperation was observed in this species of *Scarabaeus* also. Sato (1998) reported that the males of *S. catenatus* not only help the female in rolling dung balls but also take an active part in nesting thus proving bisexual cooperation. He labels this as 'mate guarding' to ward off intrusion by conspecific males.

***Sisyphus hirtus* Weidemann**

These beetles too emerged in July with the first monsoon showers and were attracted to both sheep and cow dung. The detached mass of dung was fashioned into a spheroid by compaction against the body. The dimensions of the dung ball are mentioned in Table 2.

Balls were rolled by beetles either singly or in pairs. When a single beetle rolled a ball, it pushed the ball with its hind legs while it stood on its fore legs in a head-stand position. When rolling in pairs the female pushed with its hind legs from behind while the male stood on its hind legs in front of the ball and pulled with its forelegs. The balls were rolled on varied terrain and over numerous obstacles. A pair of beetles was noticed attempting to roll a ball up a 700 slope. The beetles tumbled down the slope many times along with the ball before they finally abandoned it and flew away. Rolling over obstacles has been observed in various species (Fabre 1897; Hingston 1923; Halffter and Matthews 1966). Similarly, as observed by Puzanova-Malysheva (1956) in *Scarabaeus sacer*, *S. hirtus* too, at times, abandoned a ball that it was rolling, flew back to the dung pat, fashioned a larger ball and began rolling it in the same direction as the ball it had abandoned.

After inspecting and rejecting a number of places, a place would finally be selected and the ball buried. While the female sat on the ball, guarding it the male dug a pit with its fore tibiae and clypeus. The male then pushed the ball in, went below the ball and continued digging till it completely disappeared in the soil. The female then entered the soil and mated.

The main purpose of rolling the dung ball away from the pat might be to attract the opposite sex for mating and to ensure adequate provisioning of food for the couple during coitus. Rolling the ball away from the dung pat and burying it in the soil might reduce desiccation, and thus help in maintaining the proper consistency of dung. Heymons and Lengerken (1929) infer that rolling reduces moisture content and achieves proper consistency as preferred by *Scarabaeus*. It also reduces competition with dung buriers at the food source (Halffter and Matthews 1966).

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19. PROTEIN PROFILE OF HAEMOLYMPH FROM *APIS* SPECIES[1]

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Molecular or biochemical considerations are comparatively new tools in honeybee systematics. Though these have been extensively used in the case of *Apis mellifera* (Mestriner 1969; Mestriner and Contel 1972; Sylvester 1986; Lee *et al.* 1989; Sheppard and Berlocher 1989), not much is known about the molecular and biochemical systematic aspects of the Asian honeybee species. It is necessary to integrate morphometric, biological and behavioural data with molecular studies for valid identification of races or geographic ecotypes in case of honeybees. Keeping this in view, studies on biochemical characterizations of honeybee species and populations were carried out.

High hills worker bees of *Apis cerana* were collected from Kinnaur, Himachal Pradesh (2,500 m above msl), and of the plains from the botanical garden, Punjab University, Chandigarh (320 m above msl). *Apis mellifera* workers were taken from the maintained apiary and *Apis dorsata* from natural nesting sites from the Punjab University campus. The haemolymph of worker honeybees was sucked with an auto pipette, by pinching off between two adjacent tergites of the abdomen of the bee. It was then diluted with sample buffer in the ratio of 1:1. For protein profiling, standard technique of SDS-PAGE (Laemmli 1970) was employed.

During the present studies, nine protein fractions were

Table 1: Protein fractions in haemolymph of *Apis* species

	Standard		*A. cerana* of high hills		*A. cerana* of plains		*A. mellifera*		*A. dorsata*	
Sr. No.	Mol. Wt. (kD)	Rf. Values	Mol. Wt. (kD)	Rf. Values	Mol. Wt. (kD)	Rf. Values	Mol. Wt. (kD)	Rf. Values	Mol. Wt. (kD)	Rf. Values
1.	480	0.2765	480	0.2765	4400	0.04255	210	0.36	250	0.34
2.	67	0.48	300	0.3101	3000	0.085	41.9	0.53	67	0.48
3.	45	0.51	96	0.4468	2000	0.1276	45	0.51	45	0.51
4.	24	0.5951	67	0.48	1650	0.1489	24	0.5951	24	0.5951
5.	18	0.6170	45	0.51	1050	0.17	-	-	-	-
6.	-	-	29	0.57	400	0.29	-	-	-	-
7.	-	-	-	-	67	0.48	-	-	-	-
8.	-	-	-	-	45	0.51	-	-	-	-
9.	-	-	-	-	41.9	0.53	-	-	-	-

identified in the haemolymph of *Apis cerana* of the plains while that of the high hills showed six protein fractions. Only one fraction corresponding to molecular weight 67 kD was shared between them, and was also present in *A. dorsata*, but absent in *A. mellifera* (Table 1), suggesting that it is characteristic of Asian species. The protein profile of populations from high hills and plains of *A. cerana* was found to be very different. This is in accordance with the suggestion of Aseo and Laude (1993), that electrophoresis data has the potential for the identification of sub-species within each species and as a marker for population structures.

The presence of a larger number of protein fractions in *A. cerana* of plains is perhaps indicative of the influence of floral food sources on the haemolymph composition. The botanical garden of Panjab University, from where these bees were collected, was blooming with spring flora, including ornamentals and fruit trees such as *Prunus amygdalus*, *Prunus padam*, *Prunus domestica*. Abdel and Wahab (1970) also observed the effect of the host plant on the haemolymph composition of *Spodoptera*.

Kumar and Kamal (1999) and Kamal (2000) studied the protein composition of hypopharyngeal glands in *A. cerana* and *A. mellifera*, and also compared the protein fractions in the royal jelly. Kamal (2000) suggested a systematic significance of the variations found in these.

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20. A PREY-PREDATOR LINK BETWEEN THE ROCK BEE *APIS DORSATA* AND THE FALSE VAMPIRE BAT *MEGADERMA LYRA* GEOFFROY BASED ON THEIR CIRCADIAN RHYTHMS[1]

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During observations, in March and April 1997, at the School of Life Sciences, Jawaharlal Nehru University, New Delhi, we found Rock Bee *Apis dorsata* hives hanging from the edge of the sunshade of the fourth floor of the school building. In the evenings, we would observe the last two mass flights, (Kastberger *et al.* 1996), of the bees, for around 5 and 10 minutes. The first mass flight occurred just before sunset, and the second during sunset. Two to three minutes before the mass flight, the False Vampire Bats (*Megaderma lyra* Geoffroy) would appear and circle around the beehive ready to catch the flying bees.

Samples of both the mass flight of bees were collected (sample sizes 109, 57 and 44), using a butterfly net (attached with a long rod). The bees caught were chilled to make them unconscious and the number of workers and drones noted. Analysis of samples confirms that 78.5% of the bees were drones. The sample of an earlier mass flight showed only 4.3% drones (sample sizes 40, 38 and 37). The circadian

rhythm of the mass flight of stingless drones (worker honeybees of *dorsata* are endowed with venomous stings) and the starting of predatory forage of the False Vampire Bats coincide, thus making a prey-predator relationship possible.

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21. A NEW LARVAL FOOD PLANT OF THE COMMON ALBATROSS *APPIAS ALBINA* (BOISDUVAL), WITH A NOTE ON ITS MIGRATION IN KERALA[1]

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The Common Albatross *Appias albina* (Boisduval) is a resident of evergreen and semi evergreen forests. It is also well known for its migratory habit (Home 1935; Williams 1938; Wynter-Blyth 1957; Larsen 1978, 1987a,b; Kunte 2000; Palot *et al.* 2002; Mathew and Binoy 2002).

Lepidopteran fauna exploration at Koyilandy, during November-January 2002 and 2003 resulted in a new host plant record – *Crateva religiosa* (Capparaceae) – for the Common Albatross *Appias albina* (Boisduval) (Lepidoptera: Pieridae). Later during December-February 2005, at Vatakara, I recorded the breeding of Common Albatross on the same plant.

Common Albatross *Appias albina* (Boisduval) reportedly feeds on *Drypetes oblongifolia*, *Drypetes roxburghii and Drypetes venusta* (Euphorbiaceae). The occurrence and successful rearing of *Appias albina* on *Crateva religiosa* confirms it as a new larval food plant.

Palot *et al.* (2002) reported migration of these butterflies starting from Coorg and passing through Aralam Wildlife Sanctuary of Kerala during November-January. Mathew and Binoy (2002) further reported a migration of butterflies at the New Amarambalam reserve forest of the Nilgiri Biosphere Reserve. Palot (pers comm.) is of the opinion that from November to January there is a movement of butterflies from Coorg to Nilgiris passing through the eastern parts of Kerala. These reports confirm the dominance of Common Albatross in migratory flights.

The actual reason behind butterfly migration is still unknown. It is suggested that stimulation to migrate might be due to population outbreaks leading to depletion of host plants and adult food resources (Ford 1990; Gilbert and Singer 1975; Mathew and Binoy 2002). Nair (2005) reports the occurrence and breeding of Common Albatross outside forest areas in Kerala and also suggests the depletion of host plants as the reason for butterfly migration. The present record also strengthens this opinion.

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22. SOME OBSERVATIONS OF PLAINS CUPIDS *EUCHRYSOPS PANDAVA* ON *CYCAS CIRCINALIS*[1]

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Plains Cupid *Euchrysops pandava* is a very common butterfly found throughout India. It is a butterfly with weak flight, and one that hardly visits nectar plants. Plants of Caesalpiniaceae, Mimosaceae and other Cycads have been recorded as its host plants (Wynter-Blyth 1957). However, no specific mention is made of *Cycas circinalis* as its host

Fig. 1: a. Group of *Cycas circinalis* plants, b. Male Plains Cupid, c. *Polyrachis* sp. ant attending the caterpillar, d. Plains cupid caterpillar on *Cycas circinalis*

plant. During the second week of May 2005 I visited the Melkote Temple Wildlife Sanctuary to assess the status of *Cycas circinalis*, where I observed a number of female Plains Cupid laying eggs on the shoots, and each shoot had 5-10 eggs. The eggs were white in colour and disc-shaped. The caterpillar was woodlouse-shaped and had two different colour forms, one green and the other reddish brown.

We saw three different species of ants (*Polyrhachis* sp.) constantly attending to the caterpillars. Ants were seen tapping the lower side of the abdomen of the caterpillar, and in response the caterpillar secreted a white liquid, which was readily consumed by the ants. Sometimes three ants were seen simultaneously feeding on the white liquid from the same caterpillar. The ants defended their caterpillars very possessively.

Courtship of the Plains Cupid has also been observed on many *Cycas circinalis* (pers. obs.). Typically the males sit on the branches of *Cycas* with their wings open. Whenever a female comes the males try to draw the attention of the female by beating the wings and by following the female.

The *Cycas circinalis* is an endangered species (Sharma *et al.* 1984), and its association with Plains Cupid is an important aspect for study for its conservation (Fig. 1).

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I thank K. Manu, founder member of Mysore amateur naturalists, an NGO based in Mysore for involving me in the '*Cycas circinalis*' census that enabled me to record the interesting observation and publish the article. Mr. Sunil from Bangalore helped us in identifying the Ant species.

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23. OCCURRENCE OF GIANT ISOPOD *BATHYNOMUS GIGANTEUS* A. MILNE EDWARDS 1879 IN THE CHENNAI COASTAL WATERS[1]

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A giant isopod species was recorded in the Chennai coastal waters at a depth of less than 90 m in April 2004. The species was identified as *Bathynomous giganteus* A. Milne Edwards 1879. It belongs to the Order Isopoda and Suborder Falbelligera of the Class Crustacea. The collection of this species, generally occurring in deeper waters, from relatively shallow waters is of interest. The cause of migration of this species to shallow water is worth investigating, especially in Chennai.

Order Isopoda contains numerous species and they are classified under 95 families. Isopods generally occur on all substrata and at all depths. Most of the species occur in intertidal and shelf waters, and a few are known to occur in freshwater. The shallow water forms are often abundant beneath rocks, among sea weeds, coral rubble, mussel beds, chambers of sponges and in detritus. Normally, the size of the adult isopod ranges from 30 to 50 mm in length, but as an oddity there are deep-sea species measuring 200 to 400 mm in length. Isopods are known by various names, such as Beach Slater, Pill Bug and Scale Louse.

The occurrence of the massive isopod species *Bathynomus giganteus* is uncommon in Chennai coastal waters. This species belongs to the Family Cirolanidae. It measured 32.5 cm in length and 11.5 cm in width. The members of this family are distributed mainly in the western Atlantic Ocean, the Gulf of Mexico, the Bay of Bengal and the Arabian Sea. While the Cirolanids occur in great abundance in both temperate and tropical waters, often constituting the most numerous group, the occurrence of the giant isopod is highly sporadic and its collection rare.

The occurrence of this species was reported earlier by Srikrishnadhas and Venkatasamy (2003) in the inshore waters of Thoothukudi. The specimen collected by them measured 26.0 cm (total length) and 9.5 cm (in breadth). There are many other giant isopod species belonging to the genus *Bathynomus*, namely *B. dodereini*, *B. affinis*, *B. propinquis*,

B. docemspinosis, *B. miyarei*, *B. kapala*, *B. immanis* and *B. peter* (Tso and Mok 1991). These species are distributed in the seas of the United States and Japan.

Even though Cirolanid isopods are cosmopolitan in distribution, many species show high levels of endemism. The members of Cirolanidae are also more important for several other reasons. The family is species-rich and occurs worldwide. This species is common in threatened marine habitats, such as coral reefs and mangrove forests that are under heavy developmental pressure, playing a significant role as food for bottom feeding fishes, predators of other fishes and also as mid-sized invertebrate consumers in the food web.

Of all the Crustacean groups, the isopods are the most diverse in their body form. Isopods have only one pair of uropod. They are extremely diverse in their feeding habits. These species mainly feed on fishes, sponges, shrimps, nematodes and radiolarians. They also feed on diseased or injured fish. They also attack fishes that have been caught in commercial nets (Briones *et al.* 1991).

The capture of this giant isopod by trawlers operated in the inshore waters of Chennai at a depth of less than 90 m, is of interest. It occurs generally at depths of 300 m, the reason for its occurrence in shallower waters is worth studying.

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24. A NOTE ON THE CAPTURE OF 'GIANT ISOPOD', *BATHYNOMUS GIGANTEUS* A. MILNE EDWARDS, 1879 OFF MANGALORE COAST, INDIA[1]

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Isopods are a large, diverse order with ten named suborders and approximately 10,000 species. They are found in all seas and at all depths, in fresh and brackish waters, and on land. The Giant isopod *Bathynomus giganteus* A. Milne Edwards, 1879 (Richardson 1905) is the largest marine isopod species recorded in the world. It is reported to occur in a wide depth range from 170 to 2,140 m and grows up to 400 mm in length. *Bathynomus giganteus* was found for the first time in 1878 off the coast of Dry Tortugas in the Gulf of Mexico and is reported to have distribution off Gulf of Mexico; Atlantic Ocean; Bay of Bengal and Arabian Sea (Brusca *et al.* 1995).

The *B. giganteus* reported here was caught in a trawl net operated by deep sea trawlers off Mangalore coast from a depth of 150 m on April 07, 2004. Even though the species is reported to have a wide distribution, the incidences of their capture by fishing vessels from Indian waters are very rare. Earlier records of the species were from Thoothukudi, Tamil Nadu (Srikrishnadhas and Venkatasamy 2003) and Ezhimala, Kannur (Jacob and Narayankutty 2006). This male specimen caught off Mangalore measured 255 mm in length and 103 mm in width.

The body of *Bathynomus giganteus* is divided into three distinct regions: head (cephalon), thorax, and abdomen (pleon); the first segment of the thorax is fused to the head. The remaining seven free segments (pereonites) of the thorax comprise the pereon; each bears a pair of uniramous legs, or pereopods. The pereopods are modified for locomotion and for latching onto the prey. The abdomen primitively consists of five free segments (pleonites) plus a fused 6th pleonite + telson (pleotelson). Each pleonite bears a pair of biramous pleopods, which are used for swimming and for respiration.

They have compound eyes, two pairs of antennae, and four sets of jaws. The first antennae are uniramous and typically chemosensory; the second antennae are typically tactile structures. The sex of the *Bathynomus* species is distinguished by the presence of paired penes on the sternum of 7th pereonite in males and with the presence of a marsupium and opening of oviduct (near the base of the legs on the fifth pereonite) in female. By examination the specimen caught was identified as a male with distinguishable male sexual characters.

B. giganteus are voracious carnivores, functioning both as predators and scavengers by crawling on the silty bottom looking for dead fishes and slow moving animals. The stomach of the specimen was dissected out and examined for its content. The stomach was empty. It is reported that *B. giganteus* feeds on a variety of food organisms, fishes, sponges, shrimps, copepods, nematodes, radiolarians, and the most important food categories in all life phases was found to be fish and squid remains (Barradas-Ortiz *et al.* 2003). When caught in the net, they tear off meat from the captured fishes.

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25. *NONEA CASPICA* (WILLD.) G. DON. (BORAGINACEAE) — A NEW RECORD FOR INDIA[1]

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During one of the plant collection visits to village Dholipal, Hanumangarh district, Rajasthan. We collected *Nonea caspica* (Willd.) G. Don. near Indira Gandhi Canal. A perusal of the literature shows that this species has not been reported from India.

This paper records for the first time the occurrence of *Nonea caspica* (Willd.) G. Don. from India. It is known so far from Pakistan (Ali and Nasir 1989). The specimens have been deposited in the Herbarium, Department of Botany, Govt. Dungar College, Bikaner (Rajasthan). The identification of the species is based on Flora of Pakistan No. 191, Boraginaceae by Ali and Nasir (1989).

Nonea caspica (Willd.) G. Don. Syst. 4: 336. 1838; Riedl in Rich.f., Fl. Iran. 48: 250. 1967; Ali & Nasir, Fl. Pakistan 191: 74. 1989.

Onosma caspica Willd Sp. Pl 1(2): 775 1797; *Nonea picta* (M. Bieb.) Fisch and May., Index sem. Hort. petrop. 43. 1835, *N. nigricans auct.* Fl. or non. DC, 1846 (Fig. 1)

An ascending annual herb (up to 20 cm long), stems

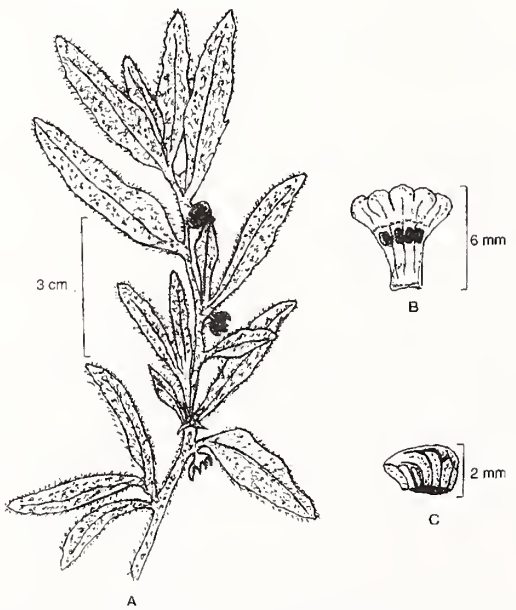

Fig. 1: *Nonea caspica* (Willd.) G. Don. (Boraginaceae) A. Twig, B. Corolla, C. Seed

and branches hairy. Leaves linear lanceolate to ovate-lanceolate, hairy especially on upper surface, entire to subdenticulate or crisp. Inflorescence elongating in fruit. Flowers blue, calyx densely pubescent. Corolla 6 mm long. cylindrical, regular, the limb indistinct. Anthers attached from corolla base. Stigma bi-fid. Nutlets black, 2 mm long, rugulose on the back, pilose.

Specimen Examined: Near Indira Gandhi Canal, Dholipal, Hanumangarh. Bhatia & Sharma, DCH 1670.

Fl. & Fr.: March-April

ACKNOWLEDGEMENTS

We are grateful to Dr. V. Singh, Joint Director, BSI, Jodhpur for encouragement. Thanks are also due to the Principal, Dungar College, Bikaner for providing lab facilities.

26. AN AMPLIFIED DESCRIPTION OF A HITHERTO UNCOMMON SPECIES *LEUCOTHOE GRIFFITHIANA* C.B. CLARKE (ERICACEAE)[1]

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As a result of revisionary work on Ericaceae in India under the 'Flora of India Project', several field trips in the Eastern Himalaya and north-eastern India as well as consultation of herbarium specimens in several Indian herbaria (CAL, BSIS, DD, BSD, ASSAM, BSHC, ARUN and APFH) were done. *Leucothoe griffithiana* C.B. Clarke, an ill-described and hitherto uncommon species, was reported for the first time in India from Arunachal Pradesh (West Kameng district) by Srinivasan (1959). Further collections were made by K. Haridasan (APFH, Itanagar) from the Lower Subansiri district in 1994. Besides BSIS and APFH, no collections were made in the above mentioned Indian herbaria so far consulted. Further collections were also made by the author (CAL) from two districts of Arunachal Pradesh, namely West Kameng and Lower Subansiri in 2002. Populations of this species are very rare in distribution; although no collections have been made from other districts of Arunachal Pradesh. The species was first described by Clarke (1882) from Tashigang district in Bhutan based on the specimen collected by W. Griffith (Kew distrb. no. 3485, CAL, K). Subsequently, the species was also reported from Western China (Flora of China, internet ed.) and Northern Myanmar (Kress *et al.* 2003).

The genus *Leucothoe* was first found and described by Don (1834) based on the type species, *L. axillaris* (Lam.) D. Don, from North America. The mythological name '*Leucothoe*' was adopted for one of the many loves of Apollo, the daughter of the King Orchamus of Babylonia (Quattrocchi 2000). According to Gray (1878), '*Leucothoe*' was "the name of one of the fifty daughters of Nereus". The genus consisting of eight species (Mabberley 1997) is confined to India, Bhutan, China, Myanmar, Vietnam, Japan and North America. Among eight species, only *L. griffithiana* C.B. Clarke is reported from two districts in Arunachal Pradesh of India.

Leucothoe D. Don, *Edinburgh N Philos. J. 17*: 159. 1834; G. Don, Gen. Syst. 3: 831. 1834; Endl., Gen. Pl.: 755. 1839; DC., Prodr. 7(2): 601. 1839 excl. sect. *Agarista* (D. Don) DC. (= *Agarista* D. Don); Hook.f. in Benth. & Hook.f., Gen. Pl. 2: 584. 1876; *A.* Gray, Syn. fl. N. Amer. 2(1): 33. 1878; C.B. Clarke in Hook.f., Fl. Brit. India 3: 460. 1882; Drude in Engl. & Prantl, Nat. Pflanzenfam. 4 (1): 42. 1889; C.E. Wood, *J. Arnold Arbor.* 42: 38. 1961; Rae in A.J.C. Grierson & D.G. Long, Fl. Bhutan 2(1): 396. 1991. Type species: *L. axillaris* (Lam.) D. Don.

Leucothoe griffithiana C.B. Clarke in Hook.f., Fl. Brit. India 3: 460. 1882; W.W. Sm., *Notes Roy. Bot. Gard. Edinburgh 13*: 164. 1921; K.S. Sriniv., *Rec. Bot. Surv. India* 17(2): 26. 1959; Rae in A.J.C. Grierson & D.G. Long, Fl. Bhutan 2(1): 396. 1991. *Gaultheria* sp., Griffith, Itin. pl. Khasyah mts. (Posthumous Papers 2): 138. 1848. *Pieris griffithiana* Hook.f. ex C.B. Clarke in Hook.f., Fl. Brit. India 3: 460. 1882, *pro syn.* Type: Bhutan, Tashigang district, towards Sanah, 2,072 m, *Griffith s.n.* (Kew distrb. no. 3485, CAL!; K, photo!) (Fig. 1).

Stout, erect, pendent shrub, 1-3 m high, rarely growing in rock crevices. Stem terete, blackish-brown, profusely branched, glabrous; branches cinnamon brown, pendent, glabrous; branchlets pinkish, terete, glabrous, often flexuosus. Leaves coriaceous, lamina oblong-lanceolate, elliptic-lanceolate to lanceolate, (9-) 12-16×3.5-4.5 cm, subentire to obscurely serrulate at margin, broadly cuneate at base, long acuminate to caudate-acuminate at apex, acumen up to 15 mm long, glabrous, dark green or pinkish-green above, light green beneath; venation brochidodromous with 7-9 pairs of lateral veins, conspicuous above, obscure beneath; petioles stout, 5-8 mm long, glabrous. Racemes axillary or rarely

Fig. 1: *Leucothoe griffithiana* C. B. Clarke
A. habit; B. flower; C-D. bracts; E-F. bracteoles; G. pedicel (part magnified); H-I. fruits; J. seed; K. rachis (part magnified); L. corolla lobe; M-N. calyx lobes; O. ovary (t. s.); P-Q. stamens; R. pistil. — Scale bars: A = 1 cm; B, H, I, R = 2 mm; C, D, E, F, J, L-Q = 1 mm; G, K = 5 mm (A-G, K-R: drawn from *Haridasan* 6841, APFH); H-J: *S. Panda* 30844, CAL. Drawn by S. Panda.

pseudoterminal, eperulate; rachis light green to greyish-white, 6-13 cm long, 20-40-flowered, densely white puberulous. Flowers 8-14 mm long; pedicels greyish-white, 3-5 mm long, densely white puberulous; bract 1, basal, greyish-white, ovate to broadly ovate, *c.* 3×2 mm, ciliolate at margin, acute at apex, glabrous; bracteoles 2, opposite, basal, greyish-white, ovate to broadly ovate, *c.* 1×1 mm, ciliolate at margin, acute at apex, glabrous. Calyx lobes greyish-white, ovate-triangular, *c.* 2×1.5 mm, ciliolate at margin, acute at apex, glabrous. Corolla tubulo-urceolate to short tubular, white, 5-6 × 4 mm, glabrous, lobes ovate, *c.* 1×1 mm. Stamens 10, *c.* 3 mm long, loosely epipetalous; filaments *c.* 1.5 mm long, slender, papillose, pilose, dilated at base; anthers oblong, *c.* 1 mm long, glabrous, each lobe with 2 equal minute apical awns. Pistil *c.* 5 mm long; ovary globose, *c.* 2×3 mm, glabrous, ovules numerous on axile placenta in each locule; disc minutely 10-dentate; style *c.* 3 mm long, slender, glabrous; stigma truncate. Capsule loculicidally 5-valved, depressed-globose, yellowish, *c.* 3×7 mm with 5-7 mm long pedicel, glabrous. Seeds numerous, winged, flattened, elliptic to suborbicular, *c.* 1 mm long, margin covered with greyish-white scale-like papillae, scariose.

Distribution: INDIA: Eastern Himalaya (Arunachal Pradesh); Bhutan; Western China and Upper Myanmar.

Habitat: This species grows gregariously in moist and humus-covered rocky slopes, sometimes hanging down from rock crevices in association with *Gaultheria seshagiriana*, *G. fragrantissima*, *G. brevistipes*, *Rhododendron vaccinioides* and *Vaccinium nuttallii* at altitudes ranging from 2,300-2,800 m .

Flowering: April-May.

Fruiting: June-December.

Specimens Examined: Arunachal Pradesh: Lower Subansiri district: Pange to Talle Valley, 2,400-2,800 m, 30.xii.2002. S. Panda 30844 (CAL); Talle Valley, 22.iii.1994, Haridasan 6756 (APFH); West Kameng district: 7 km from Bomdi La toward Dirang, 2,286 m, 26.xii.2002, S. Panda 30833 (CAL); Bomdi La, 14.v.1955, K.S. Srinivasan s.n., acc. no. 42659 (BSIS).

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I am grateful to my supervisor, Dr. M. Sanjappa, Director, Botanical Survey of India for guidance, manuscript correction and for awarding a research fellowship. Thanks are also due to Dr. K. Haridasan (Ex-Scientist, APFH, Itanagar) and Dr. A.K. Baishya (Ex-Deputy Director, ARUN, Itanagar) for providing all facilities for field studies in West Kameng and Lower Subansiri districts and for consultation of herbarium specimens at APFH and ARUN.

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27. NEW RECORDS OF FIVE TAXA OF ERICACEAE FROM INDIA[1]

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Introduction

As a result of revisionary work on Ericaceae in India under the 'Flora of India Project', several field trips in the Eastern Himalaya and north-eastern India, as well as consultation of herbarium specimens in several Indian herbaria (CAL, BSIS, DD, BSD, ASSAM, BSHC, ARUN and APFH), were done. This resulted in new records of the following five taxa of Ericaceae for the first time from India. All the five taxa are provided with key, description and illustration.

Key to the Taxa

1. Abaxial leaves punctate; flowers tetra-pentamerous in the same plant; stamens 5; each anther lobe with 2 apical awns ..... *Gaultheria tetramera*
— Abaxial leaves not punctate; flowers always pentamerous; stamens 10; anther lobes without apical awns 2
2. Leaves villous; racemes with 5-7 basal foliose bracts; filaments geniculate ..... *Lyonia ovalifolia* (Wall.) Drude var. *foliosa*
— Leaves not villous; racemes without foliose bracts; filaments straight 3
3. Twigs densely setose; leaves 3-8 cm long; filaments densely pilose ..... *Vaccinium exaristatum*
— Twigs glabrous; leaves 8-24 cm long; if leaves 8 cm long then filaments glabrous or puberulous 4
4. Leaves pseudo-verticillate; bract *c.* 5 mm long; filaments minutely puberulous; anther lobes granular ..... *Vaccinium nuttallii*
— Leaves alternate; bract *c.* 1.5 mm long; filaments glabrous; anther lobes smooth ..... *Vaccinium papulosum*

Gaultheria tetramera W. W. Sm., Notes *Roy. Bot. Gard. Edinburgh* 11(55): 211. 1919; Airy Shaw in Curtis's *Bot. Mag.* 163: t. 9618. 1942. Type: China, Yunnan, East of Tengyueh, 25° N, 1,828 m, *G. Forrest* 7702: K, photo! (Fig. 1).

Stout, bushy erect shrub, 0.2-1.5 m high, often growing in rock crevices. Stem terete, blackish-brown, profusely branched, subglabrous; branchlets light green with pinkish stripes, hispid-setose. Leaves subcoriaceous, lamina oblong, oblong-elliptic, elliptic to rarely obovate, 2.5-4.0 (-7.0) × 1.4-2.0 cm, serrulate at margin, broadly cuneate at base, mucronate at apex, dark green, glabrous above, light green with a few setose hairs and punctate beneath; venation conspicuously brochidodromous with 3-5 pairs of lateral veins; petioles stout, 2-3 mm long, sparsely setose. Racemes axillary, short, perulate; rachis greenish-white, up to 2 cm long, 6-12-flowered, densely white puberulous. Flowers tetra-pentamerous, *c.* 10 mm long; pedicels greenish-white, *c.* 4 mm long, minutely white puberulous; bract 1, basal, light

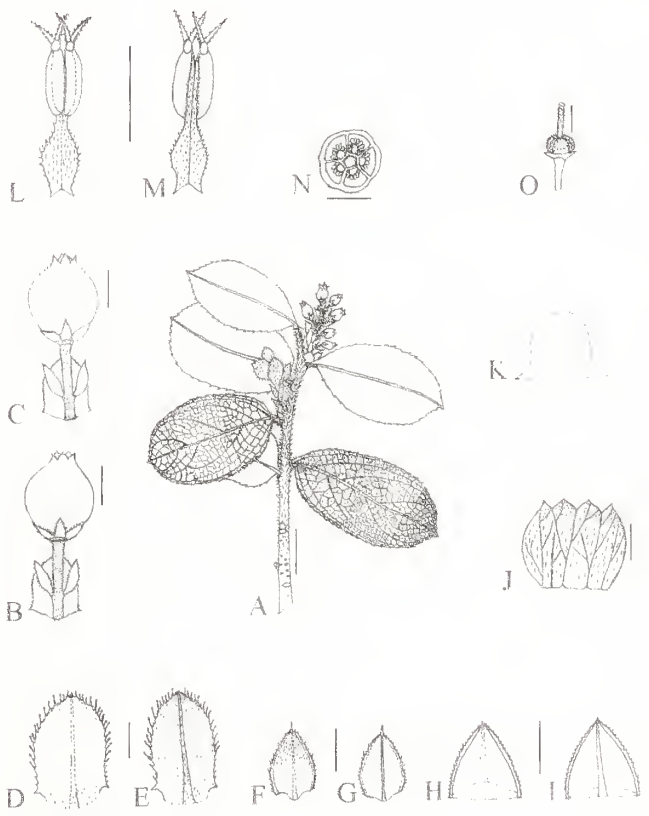

Fig. 1: *Gaultheria tetramera* W. W. Sm.
A. habit; B-C. flowers; D-E. bracts; F-G. bracteoles; H-I. calyx lobes; J. corolla split open; K. corolla lobe; L-M. stamens; N. ovary (t. s.); O. pistil.
— Scale bars: A = 1 cm; B, C, J = 2 mm; D-I, L-O = 1 mm
(A-O: drawn from S. Panda 29976)

green with pinkish stripes, ovate-oblong or oblong, *c.* 3.5 × 2.0 mm, ciliate at margin, mucronulate at apex, puberulous; bracteoles 2, opposite, sub-basal, light green with pinkish stripes, ovate-elliptic, 2 × 1 mm, ciliolate at margin, mucronulate at apex, puberulous outside, glabrous inside. Calyx 4-5-lobed, lobes equal, united at the base, pinkish, ovate to ovate-triangular, *c.* 1.5 × 1.0 mm, ciliolate at margin, mucronulate at apex, glabrous. Corolla ovoid-urceolate, pinkish-white, *c.* 5 × 4 mm, glabrous outside, pilose inside, 4-5-lobed, lobes equal and minute. Stamens 5, *c.* 2 mm long, loosely epipetalous; filaments greyish-white, *c.* 1 mm long, slender, papillose, pilose, dilated at middle; anther lobes orange brown, oblong, *c.* 1 mm long, glabrous, each lobe with 2 equal, minute, warty apical awns. Pistil *c.* 2.5 mm long; ovary globose to subglobose, light green, *c.* 1.0 × 1.5 mm, densely white tomentose, 4-5-locular, ovules numerous on axile placenta in each locule; disc obscure; style light green, *c.* 1.5 mm long, slender, puberulous; stigma truncate. Fruits not seen.

Distribution: INDIA: Eastern Himalaya (Sikkim) and SW China (Yunnan).

Habitat: This is a rare species grown in discontinuous patches on moist humus covered rocky slopes, often hanging down from rock crevices in association with *Gaultheria hookeri*, *G. stapfiana* and *G. semi-infera* at *c.* 3,200 m.

Flowering: May.

Specimens Examined: Sikkim: Lachen to Thangu, near Yangdin, 3,200 m, 31.v.2002, S. Panda 29976.

Notes: The species was first collected in 1912 by G. Forrest in the Tengyueh region of Yunnan in China and described by W.W. Smith in 1919; the species was not reported from India. Although, Airy Shaw (1942) wrote, "possibly a distinct species with longer and narrower leaves known from Sikkim"; he did not cite any specimens of this species from Sikkim. Therefore, he was unsure of its distribution from Sikkim.

The Sikkim populations (S. Panda 29976) showed *c.* 3.5 mm long, oblong to ovate-oblong bract, sub-basal bracteoles, *c.* 4 mm long pedicel and puberulous style not reported earlier.

Lyonia ovalifolia (Wall.) Drude var. ***foliosa*** (H.R. Fletcher) Judd *J. Arnold Arbor. 62*: 168. 1981. *Xolisma foliosa* H.R. Fletcher, *Kew Bull. 101*: 40. 1936. *Lyonia foliosa* (H.R. Fletcher) Sleumer, Dansk Bot. Ark. 25: 80. 1963. Type: Thailand, Loi, Kao Krading, *c.* 1,200 m, 12.iii.1924, *Kerr* 8673 (holotype and isotypes: E, *n.v.*) (Fig. 2).

Stout, erect shrub, *c.* 1.2 m high, rarely growing in rock crevices. Stem terete, profusely branched, glabrous. Leaves chartaceo-coriaceous to papery, lamina elliptic to oblong-

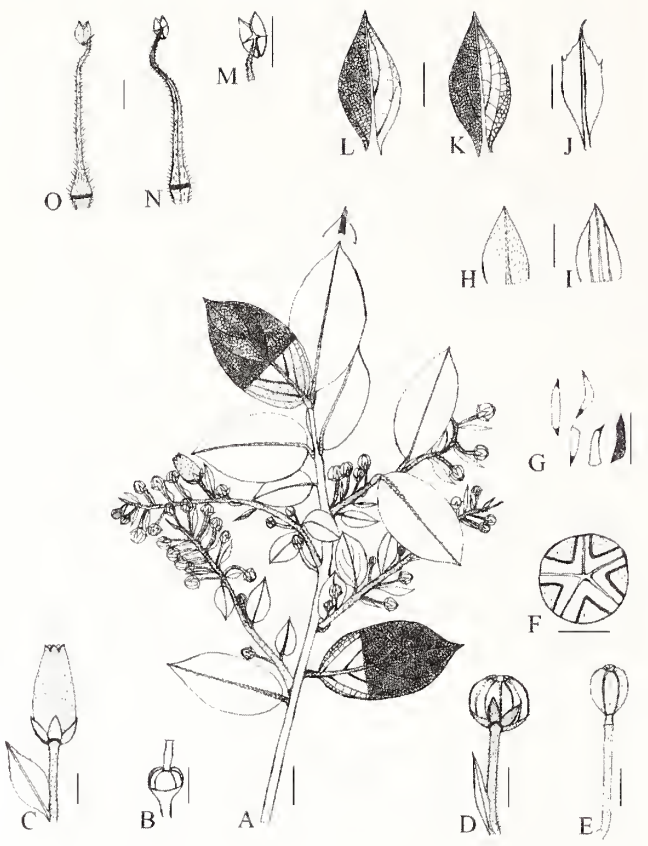

Fig. 2: *Lyonia ovalifolia* (Wall.) Drude var. *foliosa* (H. R. Fletcher) Judd
A. habit; B. pistil; C. flower; D-E. fruits; F. fruit (top view); G. seeds; H-I. calyx lobes; J-L. bracts; M. anther lobes (magnified); N-O. stamens.
— Scale bars: A = 1 cm; B, C, F, J, K, L = 2 mm; D, E = 3 mm; G, H, I, M, N, O = 1 mm (A-O: drawn from *G. Panigrahi* 3278)

elliptic, 2-5 × 1-2 cm, obscurely serrulate-ciliate at margin, rounded to broadly cuneate at base, mucronulate at apex, dark green, densely villous along mid-vein above, light green, sparsely villous beneath; venation conspicuously brochidodromous with 5-7 pairs of lateral veins; petioles stout, 2-5 mm long, villous. Racemes axillary; rachis 5-7 cm long, 12-18-flowered, puberulous with 5-7 basal foliose bracts of 7-30 mm long. Flowers *c.* 13 mm long; pedicels *c.* 6 mm long, puberulous; bract 1, basal, ovate-elliptic to oblong-elliptic or elliptic 6-8 × 2.0-3.5 mm, entire to sparsely ciliate at margin, mucronulate-acuminate at apex, glabrous; bracteoles not seen. Calyx lobes coriaceous, ovate-triangular, *c.* 2 × 1 mm, entire at margin, short acuminate at apex, villous outside, glabrous inside. Corolla tubular, white, *c.* 7 × 3 mm, villous outside, glabrous inside, lobes minute. Stamens 10, *c.* 7 mm long, loosely epipetalous; filaments *c.* 6 mm long, slender, geniculate, pilose, dilated at base, with 2 equal, opposite, minute spurs at the anther-filament junction; anthers

orange brown, elliptic, *c.* 1 mm long, glabrous. Pistil *c.* 4.5 mm long; ovary globose, *c.* 1.5 × 1.5 mm, glabrous, ovules numerous on axile placenta in each locule; disc obscure; style *c.* 1.5 mm long, slender, columnar, straight, slightly swollen near middle, glabrous; stigma truncate. Capsule globose to ovoid, *c.* 3 × 3 mm with 8-10 mm long puberulous pedicel, glabrous. Seeds numerous, blackish-brown, cylindrical, acicular to sickle-shaped, *c.* 1 mm long, scariose.

Distribution: INDIA: Meghalaya; Thailand.

Habitat: This is a rare variety that grows in discontinuous patches in dry rocky slopes in association with *L. ovalifolia* var. *lanceolata* at *c.* 1,500 m.

Flowering: April-May; September.

Fruiting: September.

Specimens Examined: Meghalaya: Nongthymai, near Shillong, East Khasi Hill district, 20.ix.1956, G. Panigrahi 3278 (Assam).

Notes: The variety was first collected in 1924 by Kerr in Loi region, Thailand, and described by H.R. Fletcher in 1936 as a distinct species, *Xolisma foliosa*. Later, Judd (1981) newly combined and changed its status as a variety under genus *Lyonia* Nutt. No record was made outside Thailand. In India, the variety is recorded from the single collection made by G. Panigrahi in 1956 from Nongthymai, near Shillong in Meghalaya. No further collections were made in India.

Vaccinium exaristatum Kurz *J. Asiat. Soc. Bengal 42(2)*: 86. 1873 (incl. var. *semipubescens* and *pubescens*) and For. Fl. Brit. Burma 2: 91. 1877. Type: Myanmar, Martaban hills, 1,600-2,000 m, Kurz s.n. (CAL !) (Fig. 3).

Vernacular names: Manipur: Ringseng (Tankul Nagas of Siroi village, Ukhrul district); Mizoram: Sirkham (Lushais of Chhimtuipui district); Nagaland: Mopungaso (Imchung Nagas of Pungro Village, Tuensang district).

Stout, erect shrub to small tree, 1-5 m high. Stem profusely branched, glabrous; branches terete, sparsely setose; twigs blackish-brown, setose. Leaves alternate, chartaceo-coriaceous to papery, lamina oblong-ovate, elliptic, ovate-elliptic to oblong-lanceolate, 3-8 × 1-3 cm, serrate to serrulate at margin, broadly cuneate to rounded at base, short acuminate to acute at apex, dark green, glabrous above, light green, glabrous or setulose along mid-vein beneath; venation conspicuously brochidodromous with 6-8 pairs lateral veins; petioles stout, 1-3 mm long, setose. Racemes axillary or pseudoterminal, eperulate; rachis light green or light green with pinkish stripes, 2-10 cm long, 10-35-flowered, pubescent to rarely glabrous. Flowers 8-14 mm long; pedicels light green, 2-5 mm long, glabrous or pubescent; bract 1, basal, caducous, pinkish, ovate-elliptic to oblong-elliptic, 1-3 × 1 mm, ciliate at margin, short acuminate to acute at apex,

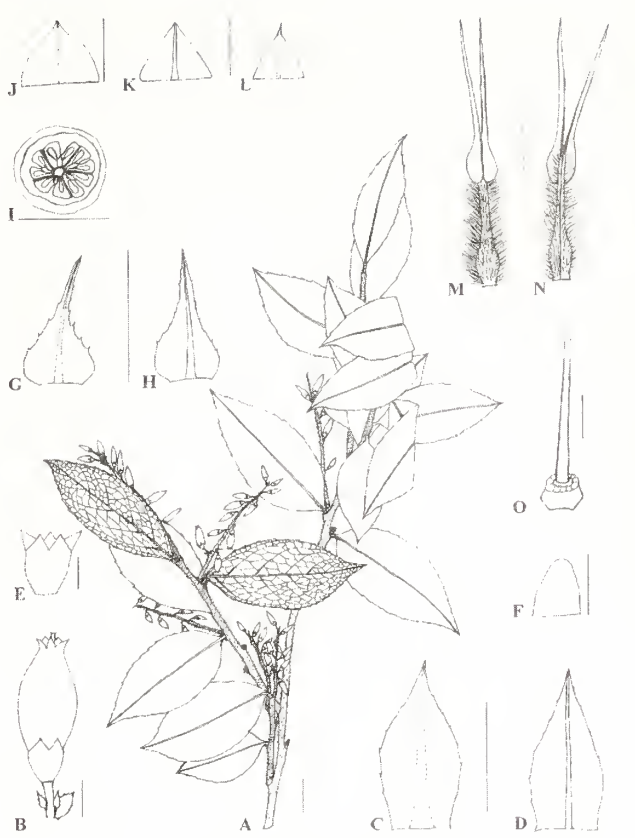

Fig. 3: *Vaccinium exaristatum* Kurz
A. habit; B. flower; C-D. bracts; E. calyx cup; F. corolla lobe; G-H. bracteoles; I. ovary (t. s.); J-L. calyx lobes; M-N. stamens; O. pistil.
— Scale bars: A = 1 cm; B, I, O = 2 mm; C-H, J-N = 1 mm
(A-O: drawn from *S. Panda* 30755).

glabrous or puberulous outside; bracteoles 2, opposite, sub-basal, caducous, pinkish, broadly to narrowly ovate-triangular, 1-2 × 0.5 mm, ciliolate at margin, acuminate at apex, glabrous or sparsely puberulous outside. Calyx lobes light green with pinkish stripes, ovate-triangular, *c.* 1 × 1 mm, entire at margin, acute at apex, glabrous or puberulous. Corolla urceolate to tubulo-urceolate, white to pinkish-white or pinkish, 5-8 mm long, 3-4 mm diameter, glabrous or rarely pilose inside, lobes ovate-orbicular, *c.* 1 × 0.5 mm. Stamens 10, 5-7 mm long; filaments pinkish-white to greyish-white, 2-3 mm long, slender, pilose, dilated at base; anthers oblong to ovate-oblong, orange brown, minute or *c.* 1 mm long, glabrous, each lobe with 2-3 mm long single tubule, spurless. Pistil *c.* 8 mm long; ovary globose, light green, *c.* 1.5 × 2.0 mm, glabrous, ovules 6-8 on axile placenta in each locule; disc minutely 10-dentate; style light green, *c.* 7 mm long, slender, glabrous; stigma truncate. Fruits not seen.

Distribution: INDIA: North-eastern India (Nagaland, Manipur and Mizoram); China; Myanmar; Thailand; Laos and Vietnam.

Habitat: This species grows gregariously in dry and moist rocky slopes, often in rocky soils in association with *Lyonia ovalifolia* var. *ovalifolia* at altitudes ranging from 800-1,800 m.

Flowering: March-April.

Specimens Examined: Manipur: Ukhrul, 1,676 m, 28.iii.1948, S.K. Mukherjee 2571; Ukhrul district: Nong Shong Khong, 914-1,219 m, 06.iv.1882, G. Watt 6259; Lambui, Ukhrul to Imphal, 1,300 m, 31.iii.2002, S. Panda 30755 and 30756; Gwaltabi, Ukhrul to Imphal road, 950 m, 31.iii.2002, S. Panda 30757; Shugnu, 30.iii.1924, *Jagarmani* 800 (DD); no precise locality, Naga hills, Kingdon-Ward 11341. Mizoram: no precise locality, Lushai hills, Mrs. Parry 15. Nagaland: Kohima ridge, 1,524 m, May, 1886, Dr. D. Prain s.n., acc. no. 264711; Kohima, 1,219 m, May, 1896, King's Collector 270; near Pungro village, Tuensang district, 1,300 m, 30.iii.2003, S. Panda 30857; Kohima, 1,463 m, 01.iv.1935, N.L. Bor 2967 (DD).

Notes: The species was first collected (date of collection so far consulted is unknown) and described by Kurz in 1873 in the region of Martaban hills in Myanmar. In India, the species was wrongly identified as *Vaccinium sprengelii* (G. Don) Sleumer in regional as well as in local Floras. At present, the species is reported from Nagaland, Manipur and Mizoram. The populations of Manipur (S. Panda 30755) showed short purple bract (1-2 mm long), 2 sub-basal and broadly ovate-triangular bracteoles, purple corolla and minute anther lobe not reported earlier.

Vaccinium nuttallii (C.B. Clarke) Sleumer in Engl., *Bot. Jahrb. Syst.* 71 (4): 477. 1941. *V. serratum* (G. Don) Wight var. *nuttallii* C.B. Clarke in Hook. *f.*, Fl. Brit. India 3: 452. 1882. Type: Bhutan, *Nuttall s.n.* (K, photo !) (Fig. 4).

Stout, erect shrub, 0.5-2.0 m high, sometimes epiphytic. Stem terete, profusely branched, glabrous, lenticillate; twigs often covered with tuft of scales up to 1 cm long. Leaves pseudoverticillate, 3-8 in each pseudoverticil, coriaceous, lamina oblong-lanceolate, lanceolate to rarely ovate-elliptic, oblong-elliptic or elliptic, (8-) 10-19 × 2.0-5.5 cm, crenate or crenate-serrate at margin, narrowly cuneate at base, acuminate, long acuminate to rarely acute at apex, acumen up to 8 mm long, glabrous, dark green above, light green beneath; venation conspicuously brochidodromous with 15-25 pairs of lateral veins; petioles subsessile to 1 mm long, glabrous. Racemes pseudoterminal, perulate, 3-6 racemes in each pseudoverticil; each rachis light green with pinkish stripes, 4-7 cm long, 25-35-flowered, glabrous. Flowers 8-13 mm long; pedicels light green, 2-6 mm long, glabrous; bract 1, basal, caducous, greenish-white with pinkish stripes, broadly ovate-triangular, *c.* 5 × 2 mm, ciliate at margin,

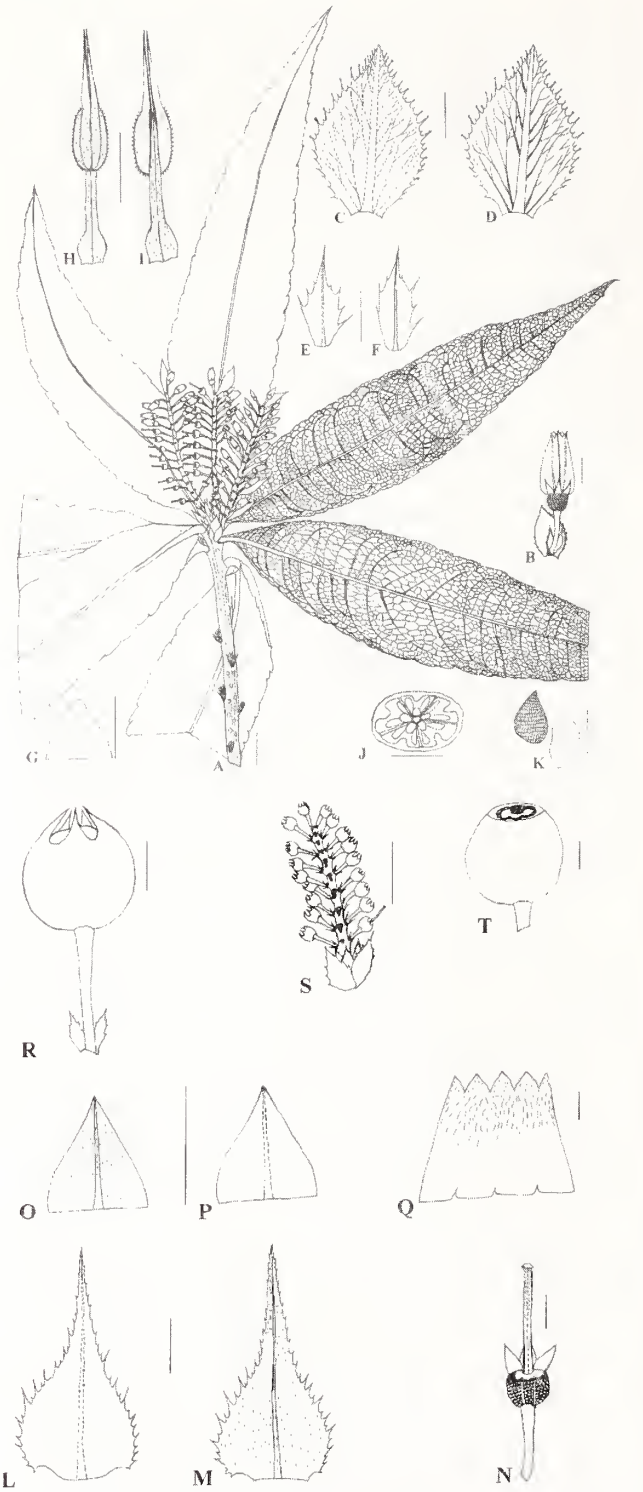

Fig. 4: *Vaccinium nuttallii* (C. B. Clarke) Sleumer
A. habit; B. flower; C-D. inflorescence bracts; E-F. pedicellar bracteoles; G. corolla lobe; H-I. stamens; J. ovary (t. s.); K. seeds; L-M. pedicellar bracts; N. pistil; O-P. calyx lobes; Q. corolla split open; R, T. fruits; S. infructescence.
— Scale bars: A = 1 cm; B – D, R = 2 mm; E-F, H-Q, S-T = 1 mm; G = 0.5 mm
(A-J, L-Q: drawn from *S. Panda* 30845A; K, R-T: *S. Panda* 30845B).

acuminate at apex, glabrous outside, puberulous inside; bracteoles 2, opposite, basal to sub-basal, caducous, greenish-white with pinkish stripes, oblong to oblong-elliptic, *c.* 2.0 × 0.5 mm, ciliate at margin, acuminate at apex, glabrous. Calyx lobes pinkish, ovate-deltoid, *c.* 1 × 1 mm, entire at margin, acute at apex, glabrous outside, puberulous inside. Corolla ovoid-urceolate, light green, 5-6 mm long, *c.* 3 mm diameter, glabrous outside, pilose inside, lobes ovate, minute. Stamens 10, *c.* 3.5 mm long; filaments greyish-white, *c.* 1.5 mm long, slender, puberulous, dilated at base; anthers orange brown, oblong, *c.* 1 mm long, granular, each lobe with *c.* 1 mm long single tubule. Pistil *c.* 5 mm long; ovary globose, light green, *c.* 1.0 × 1.5 mm, glabrous, ovules 6-8 on axile placenta in each locule; disc minutely 10-dentate; style light green, *c.* 4 mm long, slender, dotted toward apex; stigma capitate or truncate. Berry globose, purple to dark purple, 3-5 × 3-5 mm with 5-6 mm long pedicel, glabrous. Seeds 10-20, yellowish-brown, obconical, *c.* 1.0 × 0.5 mm, scariose.

Distribution: INDIA: Eastern Himalaya (Arunachal Pradesh); Bhutan and Northern Myanmar.

Habitat: The species grows gregariously on moist rocky slopes, sometimes epiphytic in association with *Gaultheria fragrantissima*, *G. brevistipes*, *G. seshagiriana*, *Leucothoe griffithiana* and *Aralia* spp. at altitudes ranging from 2,000-2,500 m.

Flowering: April-June; November-January.

Fruiting: July-September; December-March.

Specimens Examined: Arunachal Pradesh: Dibang Valley district: specimens at BSD; near Myodia Guest House, 15.xi.2000, D.K. Singh & Party 97428; west bank of Mehao Lake, 24.xi.2000, D.K. Singh & Party 97636; Myodia, 06.xii.1988, K. Haridasan 4911 (APFH); Lower Subansiri district: Daphla Hills, 20.i.1875, J.L. Lister 195; Pange to Tale Valley, 2,200-2,500 m, 30.xii.2002, S. Panda 30845A & B; Rizampaka to Saling, about 19 miles South-east of Hapoli, 17.iv.1965, A.R.K. Sashtry 42056 (ARUN); Tale Valley, 22.iii.1994, K. Haridasan 6758 (APFH); Tirap district: Nonglo, 29.vi.1961, D.B. Deb 26351; Chinnkang, 28.vi.1961, D.B. Deb 26270; West Kameng district: Chakoo, 2,465 m, 21.iv.1957, G. Panigrahi 6295; Bomdi La, 16.v.1955, K.S. Srinivasan s.n., acc. no. 42697 (BSIS); Eagle Nest Sanctuary, 06.xi.1982, K. Haridasan 1187 (APFH); West Siang district: Bulli to Shikar forest, 28.xi.1984, K. Haridasan 1822 (APFH).

Notes: The species was first collected by Nuttall from Bhutan and described by C.B. Clarke in 1882 as a variety of *Vaccinium serratum* (G. Don) Wight (= *Vaccinium vacciniaceum* (Roxb.) Sleumer). Later, Sleumer (1941) newly combined and changed its status as a distinct species, *V. nuttallii*. Earlier this species was recorded only from Bhutan and northern Myanmar. Specimens of this species from northern Myanmar were first collected by Kingdon-Ward (no. 6642, 6698, 6702). In India, this species is recorded only from Arunachal Pradesh. The populations of Arunachal Pradesh (S. Panda 30845A & B) showed broadly ovate-triangular bract with acuminate apex, densely puberulous filaments, granular anther lobes and purple berries not reported earlier.

Vaccinium papulosum C.Y. Wu & R.C. Fang *Acta Bot. Yunnan.* 9: 388. 1987; Type: China, Xizang, Medog, 1,650 m, 10.v.1983, B.S. Li, S.Z. Cheng & C.C. Ni 4828 (PE, *n.v.*) (Fig. 5).

Stout, erect or pendent, epiphytic shrub, 1-3 m high. Stem terete to angular, profusely branched, glabrous, lenticillate. Leaves alternate, coriaceous, rhomboid-elliptic, oblong-lanceolate to oblong-elliptic, 18-24 × 4-7 cm, serrate at margin, narrowly cuneate at base, acute or acuminate at apex, glabrous, dark green above, light green beneath; venation conspicuously brochidodromous with 15-20 pairs of lateral veins; petioles stout, 8-10 mm long, glabrous.

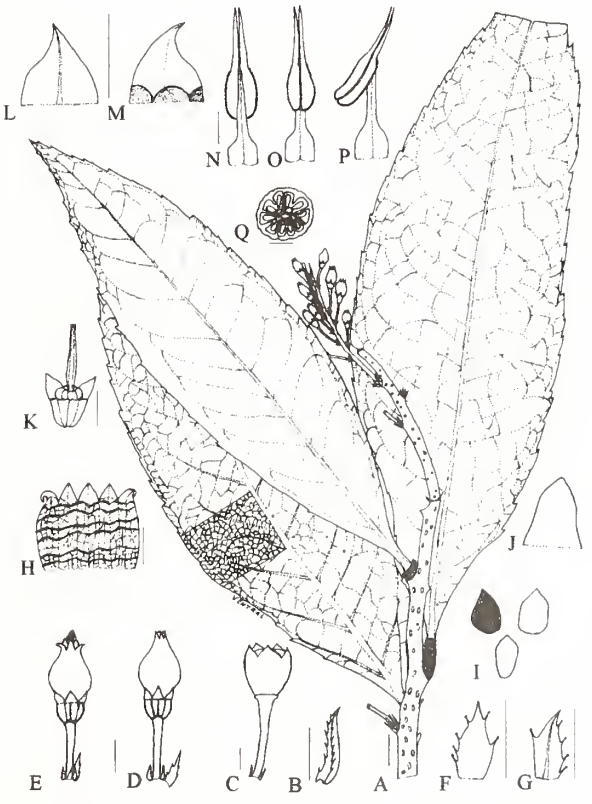

Fig. 5: *Vaccinium papulosum* C.Y. Wu & R.C. Fang
A. habit; B. bract; C. calyx cup with pedicel; D-E. flowers; F-G. bracteoles; H. corolla split open; I. seeds; J. corolla lobe; K. pistil; L-M. calyx lobes; N-P. stamens; Q. ovary (t. s.).
— Scale bars: A = 1 cm; B, F, G, L, M-Q = 1 mm; C, H, K = 2 mm; D-E = 3 mm
(A-Q: drawn from *G. D. Pal* 77800).

Racemes axillary, perulate or eperulate; rachis 4-5 cm long, 12-16-flowered, glabrous. Flowers *c.* 15 mm long; pedicels *c.* 8 mm long, glabrous; bract 1, basal, caducous, narrowly ovate-triangular, *c.* 1.5 × 0.5 mm, ciliate at margin, acuminate at apex, glabrous; bracteoles 2, opposite, basal, caducous, ovate-oblong, *c.* 1.0 × 0.5 mm, long, ciliate at margin, acuminate at apex, glabrous. Calyx lobes broadly ovate-deltoid, *c.* 1 × 1 mm, entire at margin, acuminate at apex, glabrous. Corolla ovoid-urceolate, 5-6 mm long, *c.* 3 mm diameter, glabrous, lobes equal, ovate-deltoid, minute. Stamens 10, *c.* 5 mm long; filaments *c.* 2 mm long, slender, glabrous, dilated at base; anthers oblong, *c.* 1 mm long, glabrous, each lobe with *c.* 2 mm long single tubule. Pistil *c.* 7 mm long; ovary globose, *c.* 2.0 × 2.5 mm, glabrous, ovules 6-8 on axile placenta in each locule; disc obscure; style *c.* 5 mm long, slender, glabrous; stigma usually truncate, rarely lobed. Berry globose, pinkish-white to pale green, *c.* 4 × 4 mm with *c.* 11 mm long pedicel, glabrous. Seeds 20-30, obconical, minute, scariose.

Distribution: INDIA: Eastern Himalaya (Arunachal Pradesh) and SW China.

Habitat: The species grow gregariously as an epiphyte on moss covered old tree trunks at *c.* 1,600 m.

Flowering: April.

Fruiting: May.

Specimens Examined: Arunachal Pradesh: specimens at ARUN: Begi to Amje, near Begi, Lower Subansiri district, 24.iv.1980, G.D. Pal 77800; Amje vicinity, 22.v.1966, A.R.K. Sashtry 45510.

Notes: The species was first collected in 1983 by B.S. Li, S.Z. Cheng & C.C. Ni in the Medog region of Xizang in China and described by C.Y. Wu and R.C. Fang in 1987. There was no record of the species outside China. In India, specimens of the species were collected in 1966 and 1980 before the Chinese specimens were discovered. At present, the species is recorded only from Lower Subansiri district of Arunachal Pradesh in India.

ACKNOWLEDGEMENT

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28. A LITTLE KNOWN PLANT SPECIES OF GUJARAT *TEPHROSIA COLLINA* SHARMA VAR. *LANUGINOCARPA* SHARMA[1]

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The *Tephrosia collina* Sharma var. *lanuginocarpa* Sharma is an extremely rare, endangered plant species of Gujarat, India (Kothari and Hajra 1983; Shah 1983.). The plant has been reported rare from Rajpipla, Southern Gujarat (Shah 1978). Other than this, there are no available records of the species in the flora of Gujarat (cf. Cooke 1901; Thaker 1910; Santapau 1962; Santapau and Janardhanan 1967; Bole and Pathak 1988). Above all, it is the only observation from the semi-arid tracts of Saurashtra, Gujarat (Bole and Pathak 1988). The specimen was collected during an extensive survey of the grasslands of Jamnagar district. The plants were observed on sandy silty soil. The paper describes its floral characteristics, phenology, variations, and habit and habitat distribution; photographs are provided .

Description

The two varieties of *Tephrosia collina* mentioned by Sharma (1960) are:

(i) Pods on faces and along the sutures thinly argenteo-canescent with forwardly adpressed short hairs, seeds 4-4.8 mm long, 2.5-3 mm broad, somewhat reniform in outline. ..... *T. collina* var. *collina*

(ii) Pods on faces villous and along the sutures conspicuously fringed with dull brown, stiff and almost erect short hairs of nearly equal length, seeds 3-3.2 mm broad, at one or both ends nearly truncate. .....
..... *T. collina* var. *lanuginocarpa*

There are some variations in the specimen of *Tephrosia collina* Sharma var. *lanuginocarpa* Sharma collected from

Table 1: Variations in the specimen collected from Saurashtra Gujarat (present study), as compared to the type specimen collected from Rajasthan by Sharma (1960)

Characters	Sharma (1960)	Present study (2001)
Leaf Rachis	up to 15.5 cm long	up to 9 cm long
Leaflets	9-11	7-9
Pods	6.5-8.5 cm long	3.5-6.5 cm long
Seeds	3-3.2 mm broad	2.5-3 mm broad

Saurashtra Gujarat (present study), as compared to the type specimen collected by Sharma (1960) from Rajasthan (Table 1).

Voucher specimens: INDIA, Gujarat, Jamnagar district, Jamjodhpur taluka, Motividi (Grassland), October 17, 2001, PSN/BIODIV/MED 1006, 1007, 1008, 1009, 1010, 1011 (SAUUNI = Saurashtra University)

Additional specimens examined: INDIA, Rajasthan, Ajmer district: Nagpahar Mt., alt. 370-550 m, November 4, 1959, V.S. Sharma 1130 A (Holotype: NBRI); Nagpahar Mt., alt. 370-550 m, November 4, 1959, V.S. Sharma 1130 B-C (Isotypes of the variety); Ajayasar Gate above Happy Valley. September 17, 1958, Sharma 586-B (NBRI)

Phenology and associated species: The plants were in flower from September to the end of October, and in fruit from October to November. They grew in the grassland with *Chrysopogon fulvus* (Spr.) Choiv., *Sehima nervosum* (Rottl.) Stapf., and *Crotolaria juncea* L.

Habitat and Population Status: The plant was growing on sandy silty soil loam on undulating hillocks. The species is common only to the grasslands.

Distribution: The geographical range of this species in Gujarat is restricted to two separate regions: the western group of population in Jamnagar (Motividi) and the southern group of population in Rajpipla.

ACKNOWLEDGEMENTS

We are grateful to Dr. Tariq Hussain and Dr. Bhaskar Bhatt, National Botanical Research Institute (NBRI), Lucknow for their valuable suggestions, provision of facilities and access to the literature and type specimen lying with Herbaria. We are thankful to the Saurashtra University for financial support and to the Forest Department, Jamnagar, India for necessary permission to collect the plant specimen. We thank Dr. Tushar Parmar and Mr. Sachin Sata, Department of Biosciences for their assistance during the fieldwork.

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29. ADDITIONS TO THE FLORA OF ANDAMAN AND NICOBAR ISLANDS, INDIA[1]

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Introduction

The Andaman and Nicobar Islands are a group of about 350 islands and over 200 Islets situated off the eastern coast of India in a junction box with the Bay of Bengal and the Indian Ocean on one side and South China Sea and the Pacific Ocean on the other. They are covered with lush green tropical

rain forests. These islands are also called 'Bay Islands'.

The presence of over 2000 indigenous (353 endemic taxa) and 500 exotic species of flowering plants within a land area of 8,290 sq. km is a significant feature of Andaman & Nicobar Islands. The degree of endemism is about 17.6% (Reddy *et al.* 2004).

During a botanical exploration of the North Andaman Islands, India, we recorded 14 interesting species, hitherto not recorded from the Islands (Vasudeva Rao 1986; Mathew 1998). They are being reported here for the first time with brief description.

Acalypha lanceolata Willd., Sp. Pl. 4: 524. 1805; Gamble 2: 1331(931). 1925. (Euphorbiaceae).

A much branched, erect herb. Leaves ovate-lanceolate, base cordate, serrate, apex acuminate, 2.2-2.8 x 1.0-1.4 cm. Flowers in spikes about 6 cm long. Capsule much larger than the bracts; seeds globose, smooth.

Habitat: Rare; a weed of disturbed localities.

FI & Fr.: September-March.

Specimen Examined: North Andaman, Shyamnagar: 13.xi.2001, CSR 2234 (CAL).

Andrographis paniculata (Burm.f.) Wall. ex Nees in Wall., Pl. Asiat. Rar. 3: 116. 1832 et in DC., Prodr. 11: 515. 1847; FBI 4: 501. 1884; Gamble 2: 1048(734). 1924. *Justicia paniculata* Burm.f., Fl. Ind. 9. 1767. (Acanthaceae)

An erect, much branched, glabrous herb, about 30 cm high. Leaves opposite, decussate, linear-lanceolate, 4-6 x 1-2 cm, glabrous, entire. Flowers pinkish white, in axillary particles, about 15 cm long. Capsule linear-oblong, pointed at both ends, about 2.5-3.0 cm long, glabrous; seeds 12.

Habitat: Occasional, in openings of moist deciduous forests.

FI & Fr.: September-March.

Specimen Examined: North Andaman, Mayabunder, Narial Tikri: 24.xi.2001, CSR 2355 (CAL).

Cassia absus L., Sp. Pl. 376. 1753; FBI 2: 265. 1878; Gamble 1: 403(285). 1919. (Caesalpiniaceae)

Erect annual herbs, up to 60 cm tall. Stem and leaves clothed with grey bristly viscous hairs. Leaves long petioled, leaflets 2 pairs, digitate, ovate-oblong, 2-4 x 1.0-2.5 cm, base cuneate, entire, apex mucronate. Flowers tinged red, in terminal or leaf-opposed racemes. Pods 3-5 x 0.4-0.6 cm, flat, oblique, covered with stiff glandular hairs; seeds 57, black, ovoid, shining.

Rare, in open forests.

Fl & Fr.: July-March.

Specimen Examined: North Andaman, Mohanpur: 2.xii.2001. CSR 2652 (CAL).

Caesulia axillaris Roxb., Pl. Cor.t. 93. 1798; FBI 3: 29 1. Gamble 2: 704(494). 1921.

An erect herb to 40 cm tall. Leaves glabrous, alternate, linear-lanceolate, 2-14 x 0.3-1.0 cm, with oblique secondary nerves, coarsely serrate, apex acute to acuminate; flowers axillary, solitary, sessile, pale blue; achenes winged, obovate, flat; pappus of 2 scales.

Habitat: Rare; a weed along bunds of paddy fields.

Fl & Fr.: June-December.

Specimen Examined: North Andaman, Mohanpur: 3.xii.2001, CSR 2600 (CAL).

Cleome aspera Koen. ex. DC., Prodr. 1: 241. 1824; FBI 1: 169. 1872; Gamble 1: 41(29). 1915. (Cleomaceae).

Annual ascending herbs. Leaves apically simple, basally trifoliolate, leaflets oblanceolate, 1-2 x 0.3-0.5 cm, middle leaflets bigger than the lateral leaflets, base cuneate, entire, apex obtuse. Flowers yellow, axillary, solitary. Fruit a capsule, slender, torulose, beaked; seeds many, minute, smooth.

Habitat: Rare, along openings of moist deciduous forests.

FI & Fr.: September-March.

Specimen Examined: North Andaman, Hathilevel: 24.xi.2001(650 in), CSR 2344 (CAL).

Corchorus aestuans L., Syst. Nat. ed. 10: 1079. 1759. *C. acutangulus* Lam., Encycl. 2: 104: 1786; FBI 1: 398. 1874; Gamble 1: 121(86). 1915. (Tiliaceae).

Annual, erect, hairy herbs, up to 40 cm tall. Leaves ovate, elliptic or oblong, 2-5 x 1-3 cm, base obtuse, serrate, apex acute or obtuse. Flowers yellow, axillary, solitary or 23-flowered, in leaf opposed cymes. Capsule elongate, 6-angled, septate, 3-winged, beak 3-fid, radiating; seeds numerous, dark brown, truncate.

Habitat: Occasional in disturbed lands and along bunds of dried up paddy fields.

Fl & Fr: July-March.

Specimen Examined: North Andaman, Radhanagar: 12.xi.2001. CSR 2436 (CAL).

Elastostemma cuneatum Wight, Ic. Ind. Orient. 35.t. 20911. 3: 1888. 1853 (*cuniata*); FBI 5: 568. 1888; Fischer 3: 1377 (963). 1928. (Urticaceae).

Annual dwarf herbs to 10 cm high; stems simple or scarcely branched, rooting near the base; stipules ovate. Leaf-base cuneate, margin dentate or crenate, apex rounded or subacute; upper surface with numerous cystoliths; nerved from base, subsessile. Flowers sessile, axillary, in heads.

Achenes ellipsoid, yellow.

Habitat: Occasional in semi-evergreen forests, amidst moist rocks on thin surface of soil.

Fl. & Fr.: July-December.

Specimen Examined: North Andaman, Narcondum Island, near Police Camp: 22.ix.1977, NG Nair 6201 (PBL); Paget Island: 6.xi.2001. CSR 2346 (CAL).

Evolvulus nummularius (L.) L., Sp, Pl. (ed. 2) 391 1762; FBI 4: 734; *Convolvulus nummularias* L., Sp. Pl. 157. 1753. (Convolvulaceae)

A procumbent herb, rooting at leaf axils, Leaves spiral, shortly petioled to 0.3 cm, orbicular-cordate at base, simple, entire, rounded at apex, 0.7-0.8 cm. Flowers solitary, white. Capsule subglobose, bluntly tapered at apex, glabrous; seeds 2-4, black, glabrous.

Habitat: Frequent, in moist localities along road sides and open forests.

Fl & Fr.: September-March.

Specimen Examined: North Andaman, Arial Bay: 28.xi.2001, CSR 2531 (CAL).

Hedyotis puberula (G. Don) Arn., Prigill. Pl. Ind. 342, 1836. *Oldenlandia pubernla,* G. Don, Syst. 3: 530. 1834. *O. umbellota* L., Sp. Pl. 119. 1753; FBI 3: 66. 1880. Gamble 2: 601(424). 1921. (Rubiaceae).

Annual erect herbs to 12 cm high. Leaves linear, narrow at both sides, 1-1.5 cm long. Flowers white, in umbels, 1-8 together, fruit a transversely dehiscent, bilobed capsule; seeds many,

Habitat: Frequent, in moist localities along grasses.

Fl & Fr.: September to March.

Specimen Examined: North Andaman, Dighpur: 28.xi.2001, CSR 2532 (CAL).

Lagascea mollis Cav. in Anal. Cienc. Nat, 6: 331.t.44. 1803; FBI 3: 302; Gamble 2: 703(494). 1921. (Asteraceae).

An erect, grey-pubescent, much branched herb. Leaves ovate-acute, crenate, 1.5-4.5 x 1-3 cm. Heads in clusters, white, silky, pubescent, 2-2.5 cm diameter; achenes cuneate, compressed or 3-angled, pappus a short fimbriate cup.

Habitat: Rare; a weed, near human inhabitations.

Fl. & Fr.: June-December.

Specimen Examined: North Andaman, Shyamnagar: 13.xi.2001, CSR 2278 (CAL).

Malvastrum coromandelianum (L.) Garcke in Bonplandia 5: 297. 1857; Gamble 1: 54(64). 1915. *Malva coromandeliana* L. Sp. Pl. 687. 1753. (Malvaceae).

Erect, branched under shrubs. Leaves ovate, 3-5 x 1.0-2.5 cm, 5-nerved at base, scattered hairy, base obtuse-truncate, crenate-serrate, apex acute. Flowers yellow, axillary, solitary or in terminal clusters. Fruit schizocarp, mericaps reniform, awns with paired apical hooks.

Habitat: Rare; in sandy soils and along roadsides.

Fl. & Fr.: July-March.

Specimen Examined: North Andaman, Shantinagar: 20.xi.2001. CSR 2652 (CAL).

Ocimum americanum L., Cent., Pl. 1: 15. 1755. *O. canum* Sims, Bot. Mag.t. 2452. 1823; FBI 4: 607. 1885; Gamble 2: 1111 (777). 1924. (Lamiaceae)

An annual, aromatic, glabrous herb. Leaves 3-5 x 1 cm, ovate-lanceolate, acuminate, entire. Flowers in elongated lax racemes, 12 cm long; corolla white to pale violet; nutlets ellipsoid, pitted, mucilaginous when wetted.

Habitat: Rare, along road sides.

Fl. & Fr.: September-March.

Specimen Examined: North Andaman, Swarajgram: 13.xi.2001, CSR 2398 (CAL).

Physalis angulata L., Sp. Pl. 183. 1753. *P. longifolia* auct. Pl. (non Nutt. 1837). Santap. *et al., J. Bombay Nat. Hist. Soc.* 58: 551. 1961; Gamble 2: 939(659). (Solanaceae).

Erect, widely branched, annual herbs to 60 cm tall. Stems angular-ribbed, glabrous. Leaves ovate-elliptic, base rounded or cuneate, oblique, long acuminate, glabrous, sinuate-dentate to incised, 3-8 x 2-4 cm. Flowers solitary, terminal, axillary, 1-1.5 cm long; corolla yellow with 5 small, brown spots inside; anthers violet or blue. Fruit greenish-yellow, 1-1.5 cm across. Fruiting calyx 4 cm long, 5-angled, glabrous.

Habitat: Frequent in disturbed lands.

Fl. & Fr.: June-December.

Specimen Examined: North Andaman, Mohanpur: 3.xii.2001, CSR 2602 (CAL).

Note: All the specimens deposited in PBL as *Physalis minima* L. are actually belongs to *P. angulata* (Reddy *et al.* 1999).

Toddalia asiatica (L.) Lam., Tabl. Encycl. 2: 16. 1797; Gamble 1: 150(107). 1915. *Panllinia asiatica* L., Sp. Pl. 365. 1753. (Rutaceae)

Armed straggler. Leaflets lanceolate, elliptic, 2-5 x 1-1.5 cm, thin coriaceous, base narrow, cuneate, margin entire, apex obtuse or acute, nerves obscure, mid nerve spiny below; petiole 2 cm long, armed. Male flowers in axillary panicles; females flowers in axillary or terminal racemes. Fruit small, orange-red.

Habitat: Occasional among rocks in scrub forests at higher elevation.

Fl. & Fr.: September-February.

Specimen Examined: North Andaman, Saddle peak: 24.xi.2001 (650 m), CSR 2599 (CAL).

Note: Of the two varieties described by Gamble (l.c.) our specimens belong to var. *gracilis* Gamble, which differs from var. *floribunda* Gamble in presence of mid nerve armed below, petiole prickled, leaflets narrow, thin-coriaceous, fruit much lobed.

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CONTENTS

ECOLOGICAL ASPECTS OF INDIAN SPINY-TAILED LIZARD *UROMASTYX HARDWICKII* IN KUTCH
Sutirtha Dutta and Yadvendradev Jhala 255

PREDATORS OF NON-PENAEID PRAWNS OF MUMBAI COAST
V.D. Deshmukh 266

HEPATICS AND ANTHOCEROTES (BRYOPHYTA) OF TAMIA AND PATALKOT VALLEY (DISTRICT CHHINDWARA), MADHYA PRADESH
A.K. Asthana and Virendra Nath 275

SIZE COMPOSITION AND MORPHOMETRY OF INCIDENTALLY CAPTURED SEA TURTLES AT VIZHINJAM, SOUTH-WEST COAST OF INDIA
P. Kannan and M. Rajagopalan 288

AVIFAUNA OF THE ANDAMAN ISLANDS: PRELIMINARY INVENTORY AND DISTRIBUTIONAL PATTERNS
Priya Davidar, K. Yoganand, T. Ganesh and K. Geetha Nayak 298

FAUNAL DIVERSITY IN PRAWNS AND CRABS IN DIGHA AND ADJACENT COAST IN WEST BENGAL WITH NOTES ON THE RELATIONSHIP OF THEIR ABUNDANCE WITH PHYSICO-CHEMICAL PARAMETERS
T.K. Chatterjee, Akmal Husain and Santanu Mitra 311

DISTRIBUTION AND STATUS OF THE ASIATIC BLACK BEAR *URSUS THIBETANUS* IN INDIA
S. Sathyakumar and A. Choudhury 316

STUDIES ON THE OCCURENCE, AVAILABILITY AND MARKETING OF CRAB (*SCYLLA* SPP.) BY CRAB MONITORING PROGRAMME OF RATNAGIRI DISTRICT, SOUTH KONKAN COAST OF MAHARASHTRA, INDIA
Vivek R. Vartak, Narendra D. Chogale and Sharad G. Belsare 324

ASPECTS OF NESTING BIOLOGY OF *CROCODYLUS POROSUS* AT BHITARKANIKA, ORISSA, EASTERN INDIA
G.V. Gopi and Bivash Pandav 328

NEW DESCRIPTIONS

A NEW FAIRY SHRIMP SPECIES, *BRANCHINELLA NALLURENSIS* FROM SOUTH INDIA
C.S. Velu and N. Munuswamy 334

DESCRIPTION OF A NEW SPECIES OF *CERCERIS* LATREILLE (HYMENOPTERA: SPHECIDAE: PHILANTHINAE: CERCERINI) ALONG WITH A NEW RECORD FROM INDIA
A. Coumar and Debjani Dey 339

MISCELLANEOUS NOTES 343

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